

## **Compliance Sampling Manual**

Prepared By  
Air Quality Bureau  
Environmental Protection Division  
Department of Natural Resources  
State of Iowa DNR

As adopted by the  
Environmental Protection Commission  
May 19, 1977

and revised  
January 30, 2003

# **COMPLIANCE SAMPLING MANUAL**

Prepared by:

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ENVIRONMENTAL PROTECTION DIVISION  
DEPARTMENT OF NATURAL RESOURCES  
STATE OF IOWA

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## TABLE OF CONTENTS

<u>SUBJECT</u>	<u>PAGE</u>
FIGURES PRESENTED .....	i
INTRODUCTION.....	ii
SAMPLING FACILITIES .....	I-1
EQUIPMENT DESCRIPTION .....	II-1
PRELIMINARY DETERMINATIONS .....	III-1
Velocity Traverse - Test Port Location .....	III-1
Stack Moisture Content .....	III-7
Molecular Weight of Stack Gas .....	III-10
Nozzle Selection .....	III-11
SAMPLING PROCEDURE FOR PARTICULATES .....	IV-1
Preliminary Information .....	IV-1
Source Operation and Necessary Production Rates .....	IV-2
Preparation of the Collection Train .....	IV-2
Leak Tests .....	IV-4
The Sample Run .....	IV-5
Shutdown and Sample Handling .....	IV-7
Sample Analysis .....	IV-8
Flue Gas Sampling and Analysis .....	IV-9
The Test Report .....	IV-11
Steam Generators .....	IV-13
Incinerators .....	IV-16
SAMPLING PROCEDURE FOR SULFUR DIOXIDE .....	V-1
Preliminary Information .....	V-1
Preparation of the Sampling Train .....	V-1
The Sample Run .....	V-2
Shutdown and Sample Handling .....	V-3
Sample Analysis .....	V-3
Audit Samples .....	V-4
Calculations .....	V-4
The Test Report .....	V-5
SYMBOLS AND ABBREVIATIONS.....	VI-1
BIBLIOGRAPHY .....	VII-1
<u>APPENDIX</u>	
A. Source Operation Data Forms.....	A-1
B. Calibration of the Pitot Tube.....	B-1
C. Calibration of the Dry Gas Meter.....	C-1
D. Calibration of the Orifice Meter .....	D-1
E. Measurement of Nozzle Diameter.....	E-1
F. Nomograph Operation .....	F-1
G. Data Sheets and Calculations .....	G-1
H. Departmental Rules Governing Compliance Testing .....	H-1

I. Stack Sampling Method Impinger Workup .....	I-1
J. CO <sub>2</sub> Adjustment for Incinerator Data.....	J-1
K. Opacity Monitor Drift Calculations .....	K-1

## **FIGURES PRESENTED**

<u>Figure No.</u>	<u>Title</u>	<u>Page</u>
1	Port Locations in Circular Stacks .....	I-2
2	Port Locations Rectangular Stacks or Ducts .....	I-4
3	Particulate and Gaseous Sampling Train .....	II-5
4	Pitobe (Pitot Tube/Nozzle Assembly) .....	II-6
5	Minimum Traverse Points versus Duct Diameters Up and/or Downstream .....	III-3
6	Point Locations Circular Ducts As Percentage of Traverse Diameter .....	III-4
7	Nomograph for Cfactor Determination .....	F-3
8	Operating Nomograph .....	F-4

## **INTRODUCTION**

567--25.1(9)(455B), Rules of the Department of Natural Resources, states as follows:

"Methods and Procedures. Stack sampling and associated analytical methods used to evaluate compliance with the emission limitations of Chapter 23 are those specified in the 'Compliance Sampling Manual' adopted by the Commission on May 19, 1977."

The purpose of this manual is to provide necessary information regarding test methods that are to be used for determining compliance with the emission standards of Chapter 23. The standards contained in Chapter 23 can be divided into the following two basic categories:

- (1) The federal standards of performance for new stationary sources (New Source Performance Standards aka NSPS) contained in subrules 23.1(1) and 23.1(2).
- (2) The standards for existing sources and new sources not subject to New Source Performance Standards.

The test method for particulate matter used to determine compliance with (1), the federal standards of performance for new stationary sources, are those specified in 40 CFR Part 60, Appendix A. The methods used to determine compliance with (2), existing sources and new sources not subject to NSPS, are contained in this manual. The sampling guidelines contained herein are patterned after those contained in "Method 5 - Determination of Particulate Emission from Stationary Sources" and "Method 6 - Determination of Sulfur Dioxide Emissions from Stationary Sources" as found in 40 CFR Part 60, Appendix A.

The methods used to measure particulate emissions cited in the preceding paragraph differ in that the method used to determine compliance for existing sources requires the inclusion of organic particulate matter and total dissolved solids in the impingers as part of the total particulate weight. The method used to determine compliance with new source performance standards does not require the inclusion of the impinger catch in the total particulate weight. The emission standards for sources subject to New Source Performance Standards have been developed, leading to the application of the best adequately demonstrated system of emission reduction (taking into account the cost), based upon the following definition of particulate matter:

60.2 "Particulate matter' means any finely divided liquid or solid material, other than uncombined water, as measured by the reference methods specified under each applicable subpart, or an equivalent or alternative method."

The emission standards for existing sources were developed by the Air Quality Commission based upon the following definition of particulate matter:

Subrule 20.2 "Particulate Matter. Any material, except uncombined water, that exists in a finely divided form as a liquid or solid at standard conditions."

This definition requires that the material caught in the impingers be included in the total particulate weight. This manual describes one method of obtaining and analyzing the impinger catch. A second method, Reference Method 202, has been published in the Federal register (40 CFR Part 51, Appendix M) and may be used, subject to the approval of the Administrator. In cases where the owner of the emission source can demonstrate that the impinger catch contains particulate matter resulting from chemical reaction of gaseous substances, which otherwise would not be collected in the impingers, the weight of the particulate matter resulting from such chemical reactions will be subtracted from the weight of the impinger catch for purposes of determining compliance with the applicable emission standards. For further discussion of this matter, please refer to appendix I of this manual.

Hopefully, information included in this manual will be useful in clarifying acceptable testing methods and procedures to those engaged in compliance testing within the State of Iowa. If it is felt necessary to deviate from the methods and procedures described herein, prior written approval by the Iowa Department of Natural Resources is required. These or other questions regarding specific application of information contained herein should be directed to:

Air Quality Bureau  
Environmental Protection Division  
Department of Natural Resources  
Suite 1, 7900 Hickman Road  
Urbandale, Iowa 50322  
515/242-5296

## **Sampling Facilities**

Subrule 25.1(8) - "Tests by Department" states as follows with regard to source sampling:

"Representatives of the department may conduct separate and additional air contaminant emission tests and continuous monitor performance tests of an installation on behalf of the state and at the expense of the state. Sampling holes, safe scaffolding, and pertinent allied facilities, but not instruments or sensing devices, as needed shall be requested in writing by the executive director, and shall be provided by and at the expense of the owner of the installation at such points as specified in the request. The owner shall provide a suitable power source to the point or points of testing so that sampling instruments can be operated as required. Analytical results shall be furnished to the owner."

This section of the manual elaborates on the facilities required for testing. These guidelines should be used by consulting firms and/or plant personnel engaged in stack testing for compliance demonstrations. In the case of a round stack, two ports 90 degrees apart are required. In a large stack, the diameter of which exceeds the maximum available probe length, four sampling ports will be necessary. If the stack is steel, each port would consist of a three-inch long piece of standard steel pipe welded perpendicular to the stack with the inside edge flush with the inside surface of the stack. The minimum inside diameter of each port should be four inches, which means a four inch nominal diameter standard steel pipe could be used. The end should be threaded and a cap provided for closing off the port when not in use. (see figure 1, page I-2). Testing for 10-micron aerodynamic diameter particulate matter (PM<sub>10</sub>) is becoming common. This type of testing requires a six-inch port as well as stack diameters  $\geq$  18 inches. If this type of testing is anticipated, larger ports should be installed initially. The test methods are those found in 40 CFR, Part 51, Appendix M.



## Port Locations for Circular Stacks

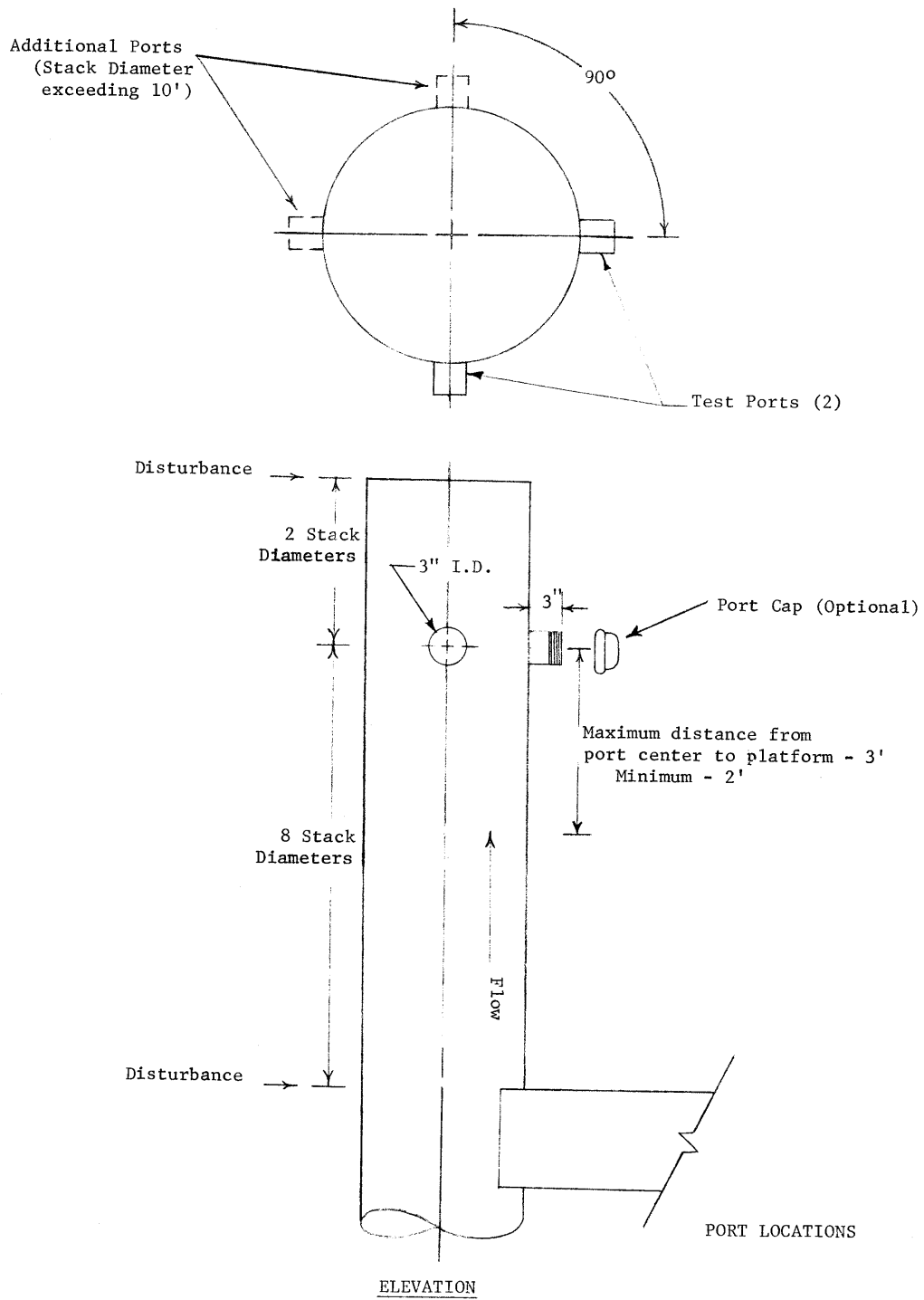


Figure 1

In the case of a rectangular stack or breaching, ports should be located in a line across one accessible side of the stack or breaching. This line must be perpendicular to the direction of flow (Figure 2, page I-4). The number of ports depends on the duct dimensions and the required number of points (see page I-4). In general, the ports are placed to obtain nearly square sampling areas for each point.

The power source should be located on the platform and at the base of the stack with a grounded weatherproof outlet. A 115 volt, 15 amp, single phase, 60 hertz ac current is desirable and extension cords should be available.

Work platforms provided should have adequate room and strength for two people and 150 pounds of test equipment. sturdy guard rails as well as a secure ladder leading to the platforms is important safety considerations. Exact dimensions and specifications for scaffolding are impossible to provide since obstructions surrounding the source to be tested often times prevent the construction of the type of scaffolding needed for ideal working conditions. However, for a stack with two portholes 90° apart, the following considerations should be kept in mind:

1. Each platform should be aligned with the porthole such that its maximum length can be utilized in sliding the sample box and probe in and out of the stack.
2. The minimum dimensions for a platform should be approximately 4' ft. by 8 ft. with a larger area desirable if possible.
3. A walkway with guardrails connecting the two platforms should be constructed to save time and manpower.
4. The ports generally should be located no less than three feet above the platform.

After the installation of sampling ports, safe scaffolding, and other necessary modifications have been completed, it is a good idea for the owner or operator to do some

## Port Locations for Rectangular Stacks

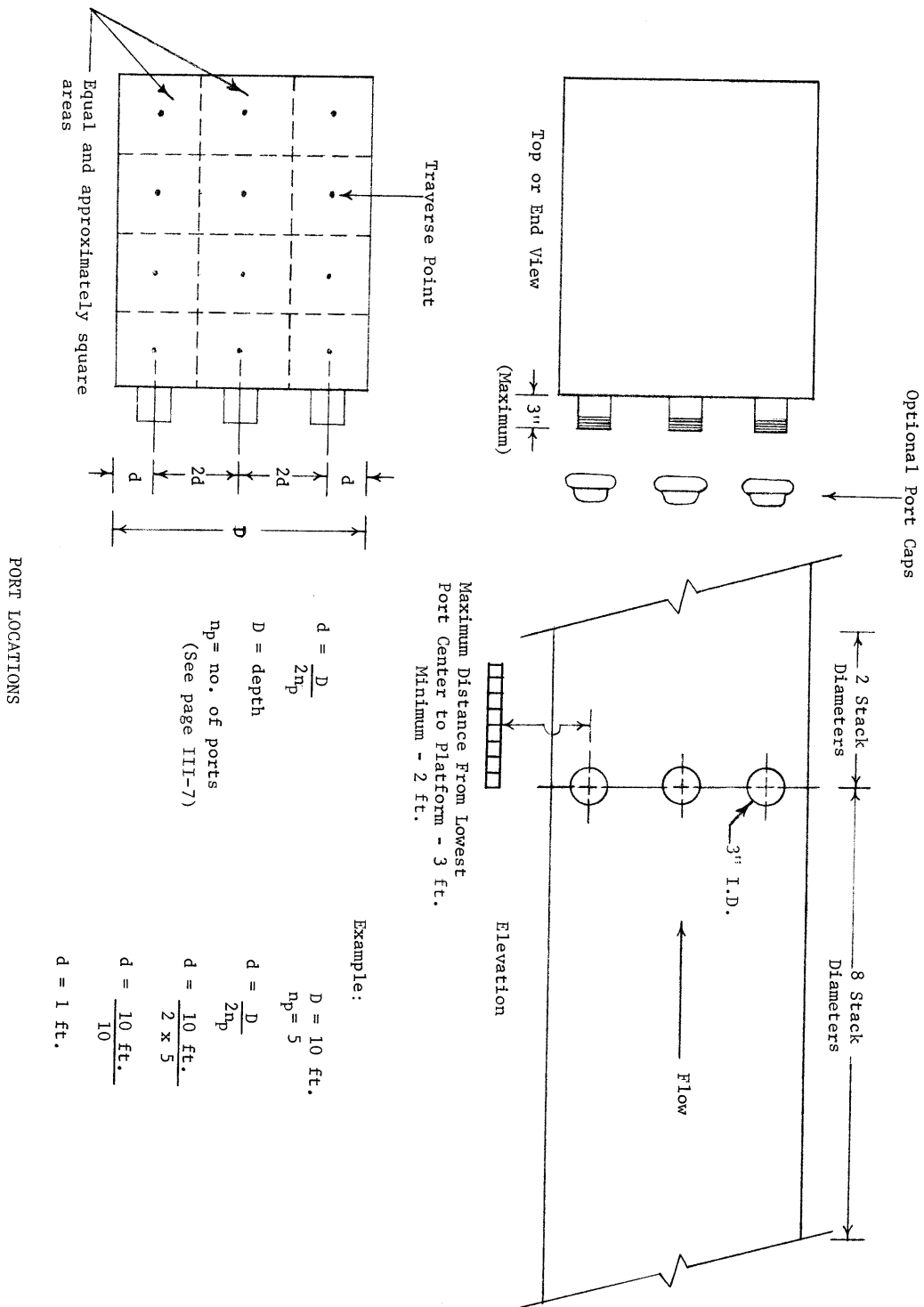


Figure 2

pretest checking. Sampling ports should be checked to see that they can be opened. Also, a check for foreign matter in the duct or stack should be made. Buildup of greasy soot or a stray piece of insulation could create turbulence around the test ports or even create extra emissions to be collected by the test equipment. Above all, the control and process equipment should be thoroughly inspected to make sure that everything is operating properly.

## **Equipment Description**

The sampling train apparatus is divided into five parts:

1. Pitobe - Combination of sampling probe and pitot tube
2. Sample Box - Contains the glass sampling equipment
3. Monorail - Supports the pitobe and sample box at the test port location
4. Umbilical Cord - Connects sample box with meter box
5. Meter Box - Contains volumetric flow meters, manometers, vacuum pump, and electrical controls for sampling.

Numbered components of the sampling train mentioned in the following discussion refer to figure ,3 page II-5, which is a diagram of the train set-up. In addition, Figure 4, page II-6, illustrates the pitot/nozzle assembly from both a side and top view.

The pitobe consists of a sample nozzle, heated probe, and pitot tube. The sample nozzle is stainless steel, and the tip is beveled 15° on the outside, creating a sharp, tapered edge, thus minimizing turbulence. The inside diameters of nozzles typically range from 1/8" to 1/2" and are designed to fit portholes with a practical minimum diameter of three inches. The shank end of the nozzle is attached by a Swagelok\* union to the probe. Some type of sealing material (fiberglass string for instance) is required between the one half inch probe liner and the Swagelok union.

The probe is a one half diameter glass (e.g. Kimax, Pyrex, or other equivalent) tube wrapped with nickel-chromium wire. High temperature resistant tape is wrapped over the wire. This wrapped Kimax tube is then inserted into a one inch diameter stainless steel tube. The Kimax tube is held in the stainless steel tube at the nozzle end by a Teflon O-ring inside a one half inch Swagelok fitting welded to the stainless steel tube. The

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\* Mention of a company or product does not constitute endorsement by the State of Iowa Department of Natural Resources.

sample box end of the glass tube is equipped with a ball joint for easy connection to the sample box glassware. The nickel-chromium wire is connected to two feet of 16 gauge insulated copper wire for connection to the sample box.

The probe is attached longitudinally to an "S" tube pitot tube situated so the openings are adjacent to the sample nozzle with 3/4" minimum clearance between the nozzle and the pitot tubes (pitot tubes and the probe are shown separately for clarity in Figure 3). The pitot tube is made from three-eighth inch outside diameter stainless steel tubing and is fitted with quick disconnects to permit rapid connection to manometer lines.

The thermocouple should be attached to the pitot tube in a manner that will not cause any interference in the measurement of the velocity pressure. An alternative is to read the temperature separately. However, this must be approved by the prior to the test.

The pitot tube is attached to a sample box that contains the glassware for particulate collection. The ball joint from the pitot tube connects to a filter, which has a collection efficiency of 99.9% at a particulate diameter of 0.3 microns. For heavy particulate loadings, a glass cyclone may be inserted before the filter. The front half of the train is maintained between 223°F and 273°F ( $248^{\circ} \pm 25^{\circ}$ ), unless specified otherwise.

The back half of the sample box consists of four impingers in an ice bath. The four impingers include one Greenburg-Smith and three modified Greenburg-Smiths. Polyethylene foam insulates the ice bath from the heated compartment and supports the impingers. A dial stem thermometer or thermocouple is used to indicate the temperature of the gas before entering the umbilical cord. For compliance testing with regard to particulate standards, it should be noted that an impinger set-up must be used rather than a condenser. The reason for this involves the definition of a particulate as stated in the rules. (See the introduction to this manual for details.)

The use of duorail angled aluminum is one effective means of supporting the sample box assembly. The duorail is erected on the sampling platform so that it is possible to slide

the sample box horizontally between the traverse points along two of the rails. Other more commonly used methods for supporting the sample box are overhead monorails or platforms rigidly attached to the stack.

The umbilical cord connects the last impinger, pitot tube, and heating elements to the meter box. It consists of four parts:

1. A 3/8 inch vacuum hose with a Swagelok connection to the meter box (connects the last impinger to the vacuum pump)
2. Two 1/4 inch lines of Tygon tubing with disconnects on both ends of the tubing (connects pitot tube to meter box manometer)
3. Four multistrand and insulated conductors with Amphenol connectors on both ends (connects sample box circuit to meter box power supply)
4. Ground wire.

The meter box contains the vacuum pump, regulating valves, instantaneous and integrating flow meters, pitot tube manometer, vacuum gauge, and electrical controls. Quick disconnect fittings connect the pitot tube lines of the umbilical cord to an inclined vertical manometer. A quick disconnect valve joins the umbilical cord sample line to the vacuum pump. The pump intake vacuum is monitored with a vacuum gauge and located directly after the quick disconnect valve. A needle valve follows the vacuum gauge and provides coarse adjustment of the gas flow. In parallel with the vacuum pump is a bypass valve that gives fine gas flow adjustment.

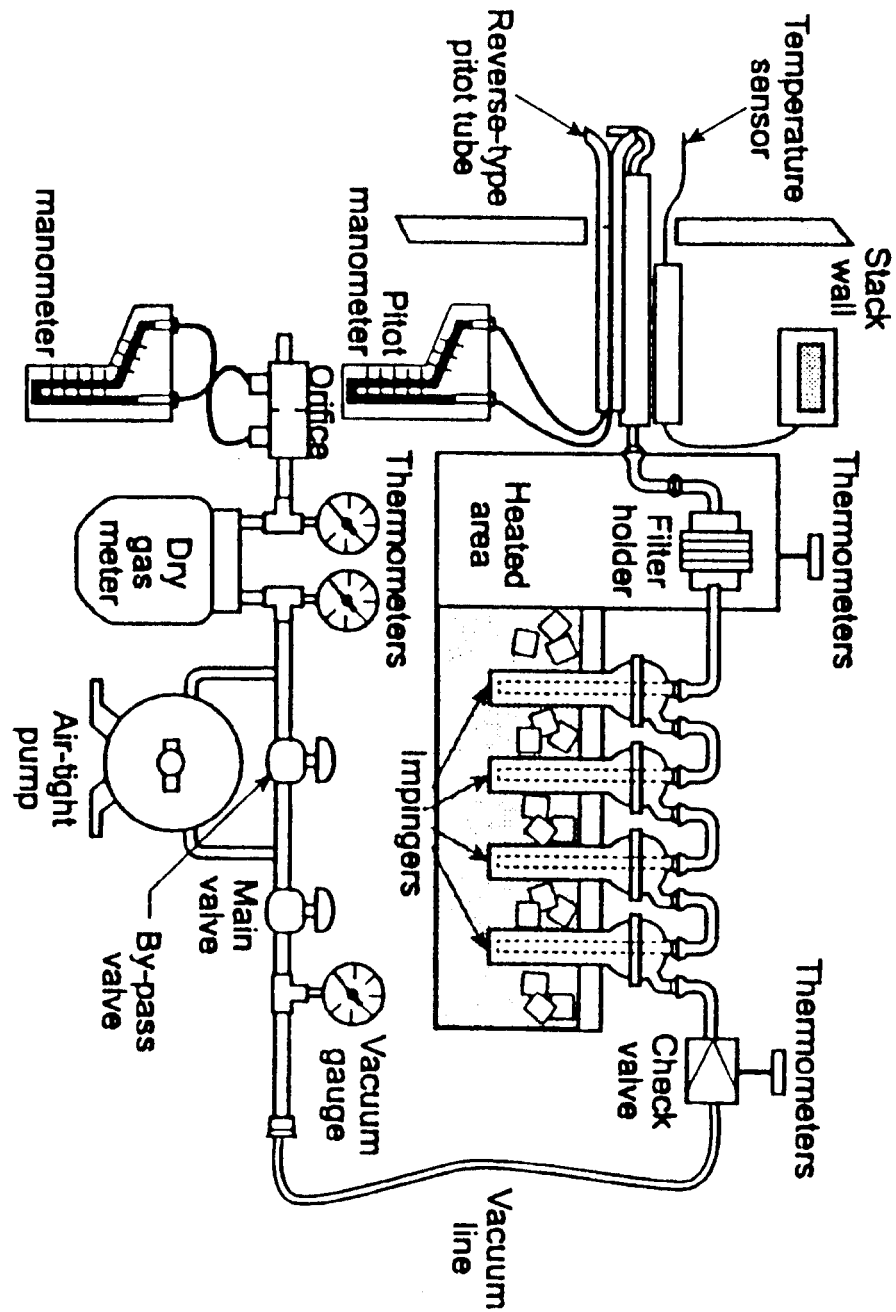
Downstream of the pump and bypass valve are inlet and outlet thermometers, a dry gas meter, and a calibrated orifice with an inclined vertical manometer in parallel. The calibrated orifice and manometer are used to indicate instantaneous sampling rates. The thermometers should be capable of measuring temperatures to within 3°F and the dry gas meter should have an accuracy of 1%.

The probe liner shall be glass unless approval for an alternative material is given by this Department prior to the actual test date. Typically Kimax, Pyrex, or other borosilicate glass is used when testing in temperatures up to 900°F. From 900°F to 1650°F, quartz should be used.

The use of alternate materials may be appropriate under certain circumstances. Most common is corrosion resistant metal (e.g. 316 stainless steel or Incoly 825). However, these must be thoroughly cleaned just prior to use to remove any oxidation. For example, if metal liners are used in very hot stacks, they must be brushed and rinsed at least six times just prior to use and thoroughly cleaned during sample recovery. Metal liners may also be used where the sampling location dictates that probes over six feet in length must be used. It will not be acceptable to use six foot metal liners when a shorter glass liner may have been used. The use of an alternate material for the probe liner without prior approval may be cause for rejection of the test.

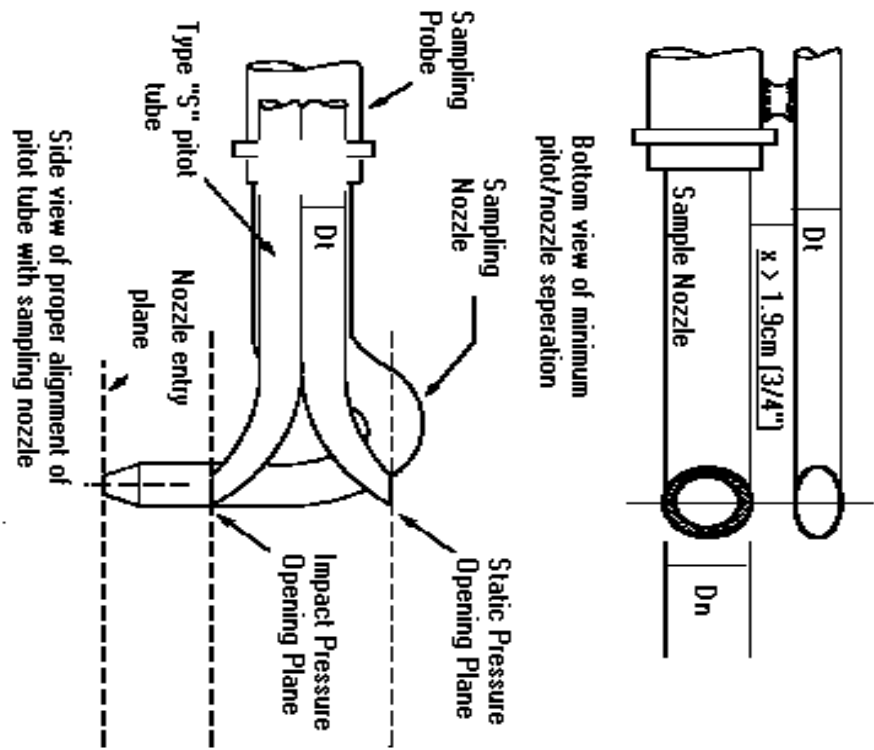


Figure 3  
Particulate Sampling Train



Proper Pitot Tube/Nozzle Alignment

Figure 4



## **Preliminary Determinations**

### **Velocity Traverse - Test Port Location**

The characteristics of the gas stream should be determined before any sampling is done. These characteristics include gas velocity, stack temperature, moisture, and molecular weight of the stack gas. Such data is important to ensure accurate, representative samples.

The preliminary measurement of velocities is the first step in the sampling procedure. Reliable velocity measurement data depends a great deal on sampling location. It is desirable to choose a sampling location in a straight section of the stack, a distance away from bends or other points of disturbance equivalent to eight stack diameters downstream and two duct diameters upstream.

When the above sampling criteria can be met, the minimum number of sampling points is twelve for ducts with diameters greater than 24 inches and eight for ducts between 12 and 24 inches. However, in many cases, it is impossible to sample at such an ideal location. If turbulence exists and another sampling location is not available, it will be necessary to increase the number of sampling points in order to obtain a representative traverse. Although the number of sampling points can be increased to ensure that the flow is representative in an area, it must be remembered that the number should be limited enough to allow the sampling to be completed in a reasonable period of time.

Figure 5, page III-3, is used for estimating the minimum number of traverse points necessary. It depends on the downstream and upstream distances from the sampling

site to the nearest disturbance. These distances are expressed in terms of equivalent stack diameters. For rectangular stacks, an equivalent diameter can be found using the following equation:

$$\text{eq.diameter} = \frac{2 * (\text{length}) * (\text{width})}{(\text{length}) + (\text{width})}$$

This equivalent diameter can be used in conjunction with figure 5 to determine the minimum number of traverse points for a rectangular stack or duct.

To use Figure 5, first measure the distances from the chosen sampling location to the nearest upstream and downstream disturbances. Determine the corresponding number of traverse points for each distance from figure 5. The greater of the two numbers of traverse points must be selected. For circular stacks, this number must be a multiple of four.

In using Figure 5, one should remember that these are guidelines that should be followed as closely as possible. In general, if the number of sample points falls between two usable values, the higher number of points should be used. Other factors which may require consideration when deciding the total number of points and the best port locations are the nature of the up and downstream disturbances, stack gas velocity characteristics, and time limitations on the sampling imposed by a cyclic type process. With regard to the minimum sampling time per point, three minutes is recommended with two minutes acceptable in certain cases where the stack gas velocities are relatively steady and uniform across the stack.

For circular stacks or ducts, the traverse points are located by dividing the area into a number of equal area concentric circles with two traverses 90° apart. On each traverse, The velocity is measured at two points in each circular area, one on each side of the center. Figure 6, page III-4 gives the distance between sampling points in terms of percentage

Number of Duct Diameters Upstream\* (Distance A)

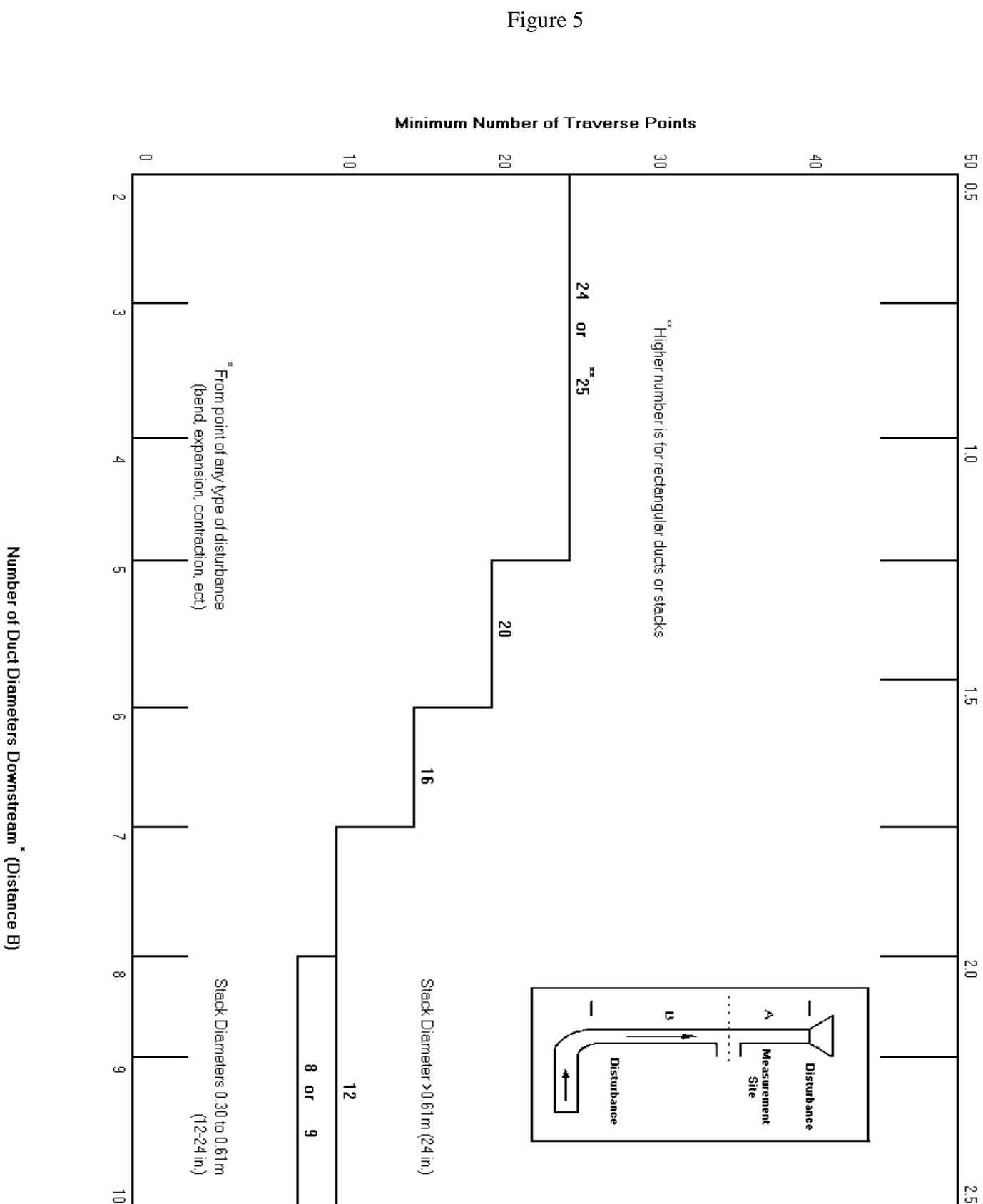


Figure 6

POINT LOCATIONS - CIRCULAR DUCTS  
AS PERCENTAGE OF TRAVERSE DIAMETER

Location of traverse points in circular stacks  
(Percent of stack diameter from inside wall to traverse point)

Traverse point on a diameter	<u>Number of traverse points on a diameter</u>											
	2	4	6	8	10	12	14	16	18	20	22	24
1	14.6	6.7	4.4	3.3	2.5	2.1	1.8	1.6	1.4	1.3	1.1	1.1
2	85.4	25.0	14.7	10.5	8.2	6.7	5.7	4.9	4.4	3.9	3.5	3.2
3		75.0	29.5	19.4	14.6	11.8	9.9	8.5	7.5	6.7	6.0	5.5
4		93.3	70.5	32.3	22.6	17.7	14.6	12.5	10.9	9.7	8.7	7.9
5			85.3	67.7	34.2	25.0	20.1	16.9	14.6	12.9	11.6	10.5
6			95.6	80.6	65.8	35.5	26.9	22.0	18.8	16.5	14.6	13.2
7				89.5	77.4	64.5	36.6	28.3	23.6	20.4	18.0	16.1
8				96.7	85.4	75.0	63.4	37.5	29.6	25.0	21.8	19.4
9					91.8	82.3	73.1	62.5	38.2	30.6	26.1	23.0
10					97.5	88.2	79.9	71.7	61.8	38.8	31.5	27.2
11						93.3	85.4	78.0	70.4	61.2	39.3	32.3
12						97.9	90.1	83.1	76.4	69.4	60.7	39.8
13							94.3	87.5	81.2	75.0	68.5	60.2
14							98.2	91.5	85.4	79.6	73.9	67.7
15								95.1	89.1	83.5	78.2	72.8
16								98.4	92.5	87.1	82.0	77.0
17									95.6	90.3	85.4	80.6
18									98.6	93.3	88.4	83.9
19										96.1	91.3	86.8
20										98.7	94.0	89.5
21											96.5	92.1
22											98.9	94.5
23												96.8
24												98.9

Occasionally a sample point location will fall within one inch of the stack wall. Under no circumstances should this point location actually be used. Instead any such point should be moved inward along the traverse to a distance of one inch from the wall. If more than one point is within one inch of the stack wall, one point should be sampled and the sampling time reduced accordingly.

As sampling in circular horizontal ducts introduces special problems, these locations should be avoided whenever possible. As discussed earlier, testing in circular ducts requires two ports oriented 90° from each other. This means that during one or both of the traverses, the sample box must be tipped to an angle that would not allow for the impingers to function properly. As an alternative, a special angled adapter between the probe and the filter holder can be used. It must be noted that in no case must a flexible connector be used at any point prior to the impingers. If a horizontal test location is selected, it is important that the Department be made aware of the testing arrangement in the preliminary information submitted with the notification of intent to test.

Sources subject to the New Source Performance Standards (NSPS), which do not require the work-up of the back half, may be able to test horizontal ducts by attaching a small heated filter assembly to the end of the probe and running a flexible connector to the impinger box. This is because the backhalf does not need to be analyzed, so the loss of particulate in the flexible connector is not a concern. While this is a legitimate procedure, prior approval must still be granted.

For rectangular stacks or ducts, the traverse points are located by forming a number of equal area rectangles. The sample should be taken at the centroid of each rectangular area. These areas should be laid out so that the ratio of length to width is not more than 1.5.

After the location of the sampling points is determined, a preliminary velocity traverse can be made. Normally an "S" type pitot tube is used to measure gas velocity in a duct of

stack. This can be corrected to correspond with the standard pitot tube once pitot tube coefficient is determined. This coefficient for an "S" type pitot tube typically ranges from 0.83 to 0.87. The coefficient varies from not only pitot tube to pitot tube, but also varies from the same pitot tube over different velocity ranges. Therefore it is important to calibrate the pitot tube in the same velocity range that is expected in actual use.

Instructions for calibrating pitot tubes are contained in Appendix B.

When taking the preliminary velocity readings, the sampler should be sure that the upstream opening in the pitot tube is lined up parallel to the stack or breaching in which it is inserted and the port opening around the pitot tube is closed off to prevent any distortion in gas flow. Erroneous readings may occur otherwise. At each point, time should be allowed for the manometer reading to adjust to the velocity change. As soon as the manometer reading is recorded, the pitot tube can be moved to the next point. Attention should be given to the stack temperatures at regular intervals. Along with the initial temperature, any changes should be noted.

Before beginning the traverse, the inclined manometer must be carefully leveled and zeroed, and it must be continuously checked to ensure it is level throughout the traverse. In zeroing the manometer, the openings for the pitot tube should be shut off from any wind currents. Also the pitot tube manometer system must be leak checked before any stack measurements are taken. This can be accomplished by gently blowing into the upstream side of the pitot tube (while watching the manometer) and, after placing your thumb over the end of the pitot tube, noting any changes the resulting static pressure. The downstream side may be checked by temporarily reversing the line connections at the manometer. Three of the most common problems encountered during testing when using the pitot tube/inclined manometer arrangement are:

1. Plugging of the pitot tube and/or lines by particulate or condensate.
2. Stack vibration causing reading and level maintenance difficulties.
3. Expansion and contraction of the manometer fluid caused by temperature changes, such as going from shade to sunlight.



If the results of each run differ significantly, they should be completed. Average preliminary velocity pressured ( $\Delta p$ ) should be recorded for each sampling point and should be compared with velocity pressures obtained during actual testing. Radical changes in  $\Delta p$ 's during a test may indicate one of the problems above. If more than ten percent of the sampling points have  $\Delta p$ 's less than 0.1 inches of water, an extended range inclined manometer should be used to measure these. An extended range inclined manometer should also be used if more than 90% of the points have velocity pressures less than 0.25 inches of water.

It has been the experience of the Department that that the use of magnahelic gauges instead of inclined manometers is unsatisfactory. This is especially true when used on the pitot line where there is a need for greater sensitivity. Approval may be given for use of magnahelic gauges for the orifice pressure or on a case by case basis for other applications, provided the test crew is prepared to conduct the calibration procedures as described in 40 CFR 60, Appendix A, Reference Method 2 on site.

### Stack Moisture Content

Since the nozzle size selection and sampling rate are both dependent on moisture content, a preliminary estimate or actual measurement of stack moisture is always necessary. As stack sampling experience is gained, it is often possible to estimate the moisture content of a specific process and control device with a fair amount of accuracy. This can save time and any minor corrections may be made after calculating the moisture content from data collected by the first test run. Three other methods that can be used to determine preliminary moisture content are:

#### 1. Silica Gel Method

A measured volume of stack gas is drawn through a plastic tube containing dry silica gel. The weight increase of the tube is the amount of water in the sample. The particulate weight is negligible. Although flow rate is unimportant, in extremely hot stacks the

sample should be drawn through the tube very slowly to prevent the silica gel from overheating, which allows moisture to pass through the tube. The silica gel should not be allowed to change color more than 1/3 of the way down.

To determine the moisture content in unsaturated gas streams, two quantities must be calculated:

$$\text{Vol. of water (STP)} = m_w * 0.047 \frac{\text{ft}^3}{\text{g}}$$

$$\text{Vol. of dry gas (STP)} = V_{dg} * \frac{530^\circ \text{R}}{T_m} * \frac{P_m}{29.92}$$

where  $m_w$  = mass of water collected in grams  
 $V_{dg}$  = volume of dry gas at metering conditions in cubic feet  
 $T_m$  = average meter temperature in  $^\circ \text{R}$   
 STP = standard temperature and pressure, 530 $^\circ \text{R}$  and 29.92" Hg  
 $P_m$  = absolute meter pressure, inches Hg

Using the above values:

$$\% \text{ moisture} = \frac{\text{Vol. of water (STP)}}{\text{Vol. of water (STP)} + \text{Vol. of dry gas (STP)}} * 100\%$$

## 2. Wet Bulb-Dry Bulb Method

This method must be limited to non-acid gas streams with a moisture content of less than 15% and a dew point of less than 126 $^\circ \text{F}$ . Two thermometers are placed in the gas stream, one dry and the other with a wet sock over the bulb. After the temperatures stabilize, they are read. The moisture content  $B_{ws}$  can be found from

$$B_{ws} = \frac{V_p}{P_s}$$

where  $B_{ws}$  = volumetric fraction of water vapor  
 $V_p$  = vapor pressure  
 $P_s$  = absolute pressure at the measuring point

The vapor pressure,  $V_p$  is found using the equation below.

$$V_p = V_{ps} - ((3.67 * 10^{-4}) P_s (t_d - t_w) [1 + \frac{(t_w - 32)}{1571}])$$

where  $V_{ps}$  = saturated vapor pressure, inches mercury  
 $P_s$  = absolute stack pressure, inches mercury  
 $t_d$  = dry bulb temperature, °F  
 $t_w$  = wet bulb temperature, °F

When the stack or duct pressure is very near atmospheric pressure, a psychrometric chart may be used to determine percent moisture. Numerous psychrometric charts and saturated vapor charts for all temperature ranges are available commercially.

In stacks where water droplets are present or a scrubber immediately precedes the sampling location, it can be assumed the gas stream is saturated. By measuring the stack temperature, the moisture can be obtained by assuming  $V_p = V_{ps}$ . If calculations of  $B_{ws}$  based on the water collected during the actual test indicate a supersaturated gas stream,  $B_{ws}$  at saturation must be used for all subsequent calculations.

### 3. Condenser Method

This method is carried out using a condenser and an integrated gas meter. The condenser should be placed in an ice bath and the temperature at the outlet of the condenser monitored. In calculating the percent moisture, the gas coming from the condenser is assumed saturated and the water collected therein is added to that condensed. This metered water is calculated from the equation:

$$V_{wm} = \frac{V_{ps}}{P_m} * V_m$$

where  $V_{wm}$  = volume of water metered in cubic feet  
 $V_{ps}$  = saturated vapor pressure at the condenser outlet, inches mercury  
 $P_m$  = absolute pressure at the meter, inches mercury  
 $V_m$  = volume of gas metered at meter conditions

The volumetric fraction of water vapor in the stack gas can then be determined from the following equation:

$$B_{ws} = \frac{(V_{wm} + V_{wc})}{(V_m + V_{wc})}$$

Where:  $V_{wc}$  = volume of water condensed in cubic feet

It should be emphasized that in all water fraction calculations the volumes used must be at the same conditions. a set of four impingers can be substituted for the condenser. The first two should be one-third full of water, the third one dry, and the fourth two-thirds full of pre-weighed silica gel. The impingers must be placed in an ice bath. In this case, the integrated gas meter would measure only dry flue gas, since the greater portion of the water vapor has been condensed out or absorbed by the silica gel. The water condensed and absorbed is measured, converted to cubic feet at meter conditions, and its fraction of the total calculated as above.

#### Molecular Weight of the Stack Gas

The most common method for determining molecular weight makes use of the Orsat. The Orsat is capable of measuring the percentages of CO, CO<sub>2</sub>, and O<sub>2</sub>. The difference is normally assumed to be N<sub>2</sub>. By changing the absorbing solutions, other components may also be measured.

After the percentages of CO, CO<sub>2</sub>, O<sub>2</sub>, and N<sub>2</sub> have been determined, the following equation is used to determine the molecular weight, M.

$$(\text{Dry}) = M_d = 0.44(\%CO_2) + 0.32(\%O_2) + 0.28(\%N_2 + \%CO)$$

$$(\text{Wet}) = M_s = M_d * (1 - B_{ws}) + 18(B_{ws})$$

$M_d$  and  $M_s$  are expressed in lbs/ lb-mole.

## Nozzle Selection

In selecting a nozzle size, use is commonly made of a nomograph, a type of alignment chart designed to relate  $\Delta H$ , the pressure drop across the orifice, with  $\Delta p$ , the velocity pressure in the stack. The nomograph is constructed so that the relationship between  $\Delta H$  and  $\Delta p$  produces an isokinetic sampling rate, i.e.  $v_s$ , the velocity in the stack, equals  $v_n$ , the velocity through the nozzle. Details on using the nomograph are provided in Appendix F.

After preliminary determinations of stack velocity, moisture content, and molecular weight have been completed, a nozzle size is picked for trial. The k-factor (pivot point) for the run to be made can then be set on the nomograph. The maximum and minimum values for  $\Delta p$  obtained from the preliminary velocity traverse can then be used to determine the range of  $\Delta H$ 's. It is desirable for this range to be between 0.3 and 6.0 inches of water for the nozzle being used since  $\Delta H$  is difficult to determine accurately above and below this range. If this criteria can not be met, the nozzle size closest should be used.

In some instances, two nozzle sizes may meet the requirements previously mentioned. The following criteria should be used in making the final determination:

1. The number of points to be sampled
2. The estimated particulate loading and particulate size
3. The desired sample time and total volume

As the ratio of nozzle tip area to stack cross sectional area decreases, the greater will be the chances of sampling in an area which is not truly representative of a traverse point area. Therefore, the largest size nozzle which conditions allow should be used. Under conditions of low gas flow rates, high moisture, low grain loadings, and a small number of traverse points, a larger size nozzle may be used. However, when a large number of points are sampled along with high gas flow rates, low moisture and high grain loadings, a small nozzle size should be used. A nozzle change may only be made at the end of a test run. Regardless of nozzle size, a total sample of at least 30 cubic feet, at standard conditions, should be collected over a minimum sampling time of one hour.

## **Sampling Procedure for Particulate**

### **Preliminary Information**

Notification of intent to test for compliance is required by IAC 567-25.1(7).

To avoid problems concerning methods and procedures, the following shall be included with the notification letter:

1. The date the test crew is expected to arrive, the date and time anticipated for the start of the first run, how many and which sources are to be tested, the place, and the names of the persons and/or testing company that will conduct the tests.
2. A complete description of each sampling train to be used, including type of media used in determining gas stream components, type of probe lining, type of filter media, and probe cleaning method and solvent to be used (if test requires probe cleaning).
3. A description of the process(es) to be tested, including the feed rate, any operating parameter used to control or influence the operations, and the rated capacity.
4. A sketch or sketches showing sampling point locations and their relative positions to the nearest up and downstream gas flow disturbances.
5. The name, address, and telephone number of the person who will be the plant contact.

As stated by IAC 567-25.1(7)(a), a pre-test meeting is required unless specifically waived by the Department.

### Source Operation and Necessary Production Rates

The source being sampled should be operated in a normal manner at its maximum continuous output as rated by the equipment manufacturer, or the rate specified by the owner as the maximum production rate at which the source will be operated. In cases where compliance is to be demonstrated at less than the maximum continuous output as rated by the equipment manufacturer, and it is the owner's intent to limit the capacity to that rating, the owner may submit evidence to the Department that the source has been physically altered so that capacity can not be exceeded, or the Department may require additional testing, continuous monitoring, reports of operating levels, or any other information deemed necessary by the Department to determine if the source is in compliance.

Maintenance and cleaning schedules/cycles should be representative of maximum production rates and should not be scheduled around an upcoming stack test. Nor should the stack test be necessarily scheduled after an annual shutdown for cleaning, etc. Operation of the source should be limited to plant personnel normally present for that purpose. Design engineers, consultants and equipment manufacturer personnel who are present should limit their comments to equipment failures, breakdowns, and the general physical condition of the equipment.

Process weights, production rates, etc., and all data necessary for relating them to allowable emission rates are to be provided by plant personnel and are to be included in the report (see Appendix A).

### Preparation of the Sampling Train

Before assembling the sampling train, all glassware should be clean and dry. The glass liner in the probe (if such a probe is used) should be washed and the nozzle attached. A glass fiber filter is labeled, desiccated for 24 hours, and weighed to the nearest 0.0001 gram. Generally the filter holder (Figure 3, page II-5) is from 2.5 to four inches in diameter.

The tared filter is placed in the filter holder and the clamps tightened around the filter holder to prevent leakage around the rubber gasket.

The first, third, and fourth impingers are modified Greenburg-Smith impingers, the standard tip removed and the straight glass tube extended to one-half inch from the bottom of the impinger. The second impinger is a standard Greenburg-Smith. One hundred milliliters (ml) of water are placed in each of the first two impingers and the third impinger is left empty. Approximately 200 grams (gm) of pre-weighed silica gel or Drierite are placed in the fourth impinger. The impingers are weighed to 0.1 gm before and after sampling.

Mark the probe with heat-resistant tape or by some other method to denote the proper distance into the stack for each sampling point. A temperature probe is attached to the metal sheath of the sampling probe so that it remains at least two inches behind the pitot tube openings and does not touch any metal. During sampling at those points less than two inches from the stack wall on the port sides, temperatures should be assumed to be the same as those immediately adjacent. Where temperatures are relatively uniform throughout the cross-sectional area of a duct or stack, a long stem dial thermometer can be used to monitor stack temperature. The placement of the thermocouple in any position other than that specified will be allowed if calibrated according to the Quality Assurance Handbook for Air Pollution Measurement Systems, Volume III.

In assembling the train, the lower half of all male ball-joints should be greased with a very light coat of silicone grease (acetone nonreactive - See Figure 3, page II-5). This insures a vacuum tight seal. After the cover from the ball-joint on the probe is removed and silicone grease applied, the probe is connected to the cyclone. The probe is secured by tightening the probe holding clamps. In addition, all ball-joint connections in the glassware assembly should be secured with clamps.



All necessary electrical and pitot tube line connections should be made. Set the variable transformer on the meter box so the desired probe temperature is obtained and turn on the heater, blower, and probe switches on the meter box. The heater should be adjusted to provide a gas temperature of about 250°F at the probe outlet. The impinger section of the sample box is filled with ice and a little water. More ice should be added during the run to keep the temperature of the gases leaving the last impinger at 68°F or less. Temperatures above 70°F will result in inaccurate moisture determinations and may result in damage to the dry gas meter from either moisture condensation or excessive heat. Both the sample box and probe should be preheated to 248°F (+/- 25°F) before starting the pump.

### Leak Tests

After the collection train has been assembled and preheated, a leak test should be run before any sample is taken. Connect the vacuum line of the umbilical cord to the inlet of the meter box and outlet of the last impinger. Place a stopper in the cyclone inlet. Before starting the pump, turn the coarse-adjust valve on the meter box to the off position and open the fine - adjust valve (by-pass valve) until fully opened. Start the pump. Partially open the coarse-valve and then slowly close the fine-adjust valve until the vacuum gauge reads 15 inches of mercury. If the flow through the dry gas meter exceeds 0.02 cfm at fifteen inches of mercury gauge pressure, the leak or leaks must be corrected. After completion of the leak test, first remove the stopper from the cyclone inlet and immediately turn off the pump. This prevents the water in the impingers from being forced backward into the filter and cyclone. A leak check is required immediately before and after a filter change or disassembly and reassembly of any other part of the sampling train during any given run. After completion of the run, a final leak check is required before dismantling the sampling train and before significant cooling takes place. Again, stopper the cyclone inlet and proceed as above. This check should be made at the highest vacuum realized during the run or five inches mercury vacuum whichever is greatest. If the flow exceeds 0.02 cfm, the run must be repeated, or corrected with the approval of the Administrator.

In addition to the above leak checks, a leak check from the nozzle is required to be conducted at five inches of mercury vacuum before each run. The leak check after the run must be conducted at at least the highest vacuum used during the test run. The flow must not exceed 0.02 cfm.

### The Sample Run

In order to qualify as proof of compliance, three separate equally trustworthy sampling runs must be made. These should consist of a minimum of one-hour sampling time, 30 scf stack gas sampled (minimum) and, the test results should agree within a reasonable range considering the process being tested. Any wide variation of results should be explained.

Before sampling is started, all preliminary data should be filled in on the data sheet (see Appendix G for information regarding data sheets and calculations). This includes the initial dry gas meter reading. The probe should be positioned at the point nearest the back wall. This allows the probe to cool somewhat in hot stacks as it comes out, shortening the cooling off period following the completion of a sample run. This also allows for the use of stack heat to heat the probe. Care should be taken to make sure that the nozzle does not hit the back wall or the inside of the port since deposited material at these points can easily contaminate a sample.

After positioning the probe, the operator should record the time and start the run by turning on the pump. Each point should be sampled from two to five minutes. The  $\Delta H$  is calculated by using the nomograph (see Appendix F, page 4), or other means and set on the meter box by adjusting the coarse and the fine-adjust valves. A rag should be stuffed into the portholes around the probe to prevent any interference with the normal gas flow. This is especially important when sampling in a particularly high or low static pressure region. When sampling a source with a high static pressure (greater than 5" water), turn on the pump before inserting the probe into the stack. In addition, the probe should be removed from the stack before the pump is turned off. Additional sealing-off procedures may be required where static pressures are excessive. During the sample traverse, the probe is generally

moved from point to point without turning off the pump except when changing ports. The  $\Delta p$  should be monitored at each point and adjustments in the  $\Delta H$  reading made accordingly. Besides the regular time interval recordings, each set of readings should be recorded and a new  $\Delta H$  set when the  $\Delta H$  changes by more than 20%. In addition, the stack temperature, gas meter inlet and outlet temperatures, and the gas meter reading must be recorded at each point. Since the gas meter reading is constantly changing, it must be read when the timer indicates the point change is taking place. The probe should be moved within ten seconds of the indicated time and the new  $\Delta H$  set as quickly as possible. Under no circumstances should the time taken to move the probe and adjust the  $\Delta H$  exceed ten percent of the sampling time per point. If the manometer reaction time is unusually slow or if the control box operator feels he can't adjust the  $\Delta H$  quickly enough, the pump should be shut off between points. One should make a special effort to adjust the  $\Delta H$  quickly when the velocity pressure makes a substantial decrease from one point to the next because the sampling rate is initially high compared to that desired and the resulting percentage error in isokinetics can be very large.

The recommended sequence of events for moving a sampling probe from point to point is as follows. Approximately ten seconds before the timer reaches "time zero", the operator should signal the person(s) on the stack to move the probe. At "time zero", the operator should read and record the integrated gas meter reading. By the time he does this the probe probably will have been in its new position long enough for the pitot tube manometer to be steady at the new velocity pressure. The nomograph is used to obtain the new  $\Delta H$  which should be set before it is recorded on the data sheet. With practice, this whole procedure should take less than twenty seconds.

After the last point is sampled, the operator should close the coarse valve, turn off the pump,

and record the final meter reading. The probe should be plugged at both ends as soon as possible since condensate will sometimes collect in the probe and wash out particulate matter if the probe is tipped. It should be remembered that the particulate in the probe usually represents a significant portion of the total sample.

Should mechanical or electrical trouble develop within the sampling train during the run, one should shut the coarse valve, shut off the pump, withdraw the probe from the flue, and cap the nozzle. The time should be noted and the fault then corrected. Sampling should be resumed at the same position noting the outage time on the data sheet for future reference.

#### Shutdown and Sample Handling

At the completion of a run, the heater, blower, and probe switches should be turned off. After removing the probe from the stack, leak tests must be run as described on page IV-6 before dismantling begins. The probe can then be disconnected and plugged at both ends to simplify transport to the clean-up site. It is recommended that before dismantling the sample box, the collection system be purged with air for ten minutes. Finally, the last impinger outlet should be plugged.

The probe should be rinsed using acetone and/or distilled water, depending on the solubility of the residue. If acetone is used, a blank should be run to make certain that the acetone does not contain contaminants that might bias the sample. Acetone which has a residue greater than 0.001 percent is not acceptable. The probe is rinsed with the aid of a probe brush of appropriate length and the rinsings are continued until the probe discharge is clear. One should then look down the center of the lining toward a bright light to be certain it is clean.

The outside of all four impingers should be wiped dry and weighed to the nearest 0.1 g. By subtracting the initial weights recorded for each impinger prior to testing from these final weights, the total moisture collected can be calculated. After the impingers have been weighed, water from the first three impingers is transferred to Container #2 followed by water and/or acetone rinsings of each. Choice of solvents again depends on the solubility of the residue. The desiccant from impinger #4 may be removed and placed in a drying oven at about 350°F for two hours so that it may be reused in a later test.

The filter should be carefully removed from the filter holder and placed in Container #3. Filter material adhering to the gasket should be carefully removed and placed in Container #3. This container should then be sealed with tape. The recovery of the filter must be done in a clean, wind-free environment, preferably in a laboratory-like setting.

### Sample Analysis

The washings from the front half of the train, Container #1, should be evaporated to dryness. Gentle heating, preferably over a steam bath, can be used to accelerate the evaporation process. Boiling of the water must be avoided. The sample should then be desiccated for 24 hours and weighed to a constant weight, which means two successive weightings within 0.5 mg. The average of the two weightings that meet this criteria should be used. This weight should be reported to the nearest 0.1 milligram (mg). Container #2, the impinger catch, should first be analyzed for organic particulate. This is done by extracting the organic particulate from the impinger solution with three 25 ml portions of ethyl ether followed by three 25 ml portions of chloroform. The ether and chloroform extracts are combined and transferred to a tared beaker. The solvent is evaporated at 70°F. This may be accomplished by blowing air filtered through activated charcoal over the sample. The beaker is then

desiccated for 24 hours, weighed to a constant weight, and the results reported to the nearest 0.1 mg. If several organic extracts indicate a negligible amount of organic particulate, or if previous information on a certain process definitely indicates negligible organic particulate emissions, it is not necessary to continue the extract analysis.

The impingers are next analyzed for inorganic particulate. The impinger water is evaporated to dryness in a tared beaker using the procedure described on page IV-9 and 10 for Container #1. The residue is desiccated for 24 hours after which it is weighed to a constant weight and the results reported to the nearest 0.1 mg.

The filter from Container #3 should be transferred along with any loose particulate to a tared glass weighing dish and desiccated for 24 hours. Then the filter should be weighed to a constant weight and the results reported to the nearest 0.1 mg. The total particulate weight is the total of the sample weights calculated from analysis of Container Numbers 1, 2, and 3.

Before making a second test run, the following should be checked:

1. Check the moisture content and stack temperature to see if they are as expected.
2. See how close the first run was to isokinetic conditions. The acceptable isokinetics range is 90% to 110%.
3. Check the velocities to see how they compare with the preliminary velocity traverse.

#### Flue Gas Sampling and Analysis

During the sampling period, an integrated sample should be taken of the flue gas for an Orsat analysis of CO<sub>2</sub>, O<sub>2</sub>, and CO (if necessary), or grab samples should be analyzed at

various intervals during the actual testing.

A Tedlar or equivalent bag is used if collection is desired. Most sampling boxes include a line and a regulator for filling the bags. Before sampling, the Tedlar bag is evacuated with the vacuum pump and the sampling line is purged. Any convenient proportional sampling rate may be used as long as the bag does not fill before the end of the test run. The sampling rate shall be adjusted in direct proportion to any changes in velocity which will require a pitot tube reading.

The Orsat analyses of CO<sub>2</sub>, O<sub>2</sub>, and CO concentrations should be run as soon as possible. Make as many passes as needed to give constant readings. If more than ten passes are necessary, the absorbing solution should be replaced. The analysis should be continued until three consecutive samples vary no more than 0.2% by volume.

Continuous collection would be preferred when sampling flue gas from a changing source such as an incinerator. However, if frequent checks are made, approximately one every three to five minutes, flue gas analysis at the site during the emission testing would be satisfactory. Approximately six grab samples per hour would be adequate on a source having a fairly constant flue gas composition.

When testing a boiler or any other combustion source where fuel composition is known or can be determined a calibrated oxygen analyzer can be used in lieu of the Orsat following Reference Method 3A.

## The Test Report

Results of each test shall be submitted to the Department in the form of a test report within six weeks of completion of the fieldwork. This report shall include but not be limited to the following information:

1. The applicable state or federal regulation.
2. Test results in tabular form using the units of measurement of the applicable state or federal regulation(s)
3. A copy of all original field data sheets used during the test
4. Calibration data and calculations (all dated) for the pitot tube, dry gas meter, orifice, and nozzle(s) used.
5. Sufficient information concerning actual source and control equipment operating conditions during the field tests so a comparison of the test results with those estimated from operating data can be made. The facility owner or his representative should certify source and control equipment operating data taken during the test. (see Appendix A)
6. A sample of all formulas used in calculating results.
7. Evaluation of the accuracy of the results (isokinetics, ect.).
8. A sketch showing the test port location relative to flow disturbances, stack diameter, ect.
9. A line flow diagram of the process showing stream flow rates during the testing, in appropriate units, and indicating the source of the information (estimate, specifications, measured, ect.).
10. In cases where the owner of the emission source wishes to demonstrate that the impinger catch contains particulate matter resulting from chemical reactions of gaseous substances (see page iii, paragraph 3), supportive



evidence, including test data and calculations, shall be submitted with the test report.

The test report shall be reviewed by appropriate Departmental staff and decisions regarding acceptance of the test as proof of compliance shall be dependent on the following conditions:

1. If the test results indicate compliance with applicable State regulations and the tests were conducted in a manner acceptable to the Department, the source in question shall be considered to be in compliance with those regulations.
2. If the test results indicate non-compliance with applicable State regulations and the tests were conducted in a manner acceptable to the Department, the source in question shall be considered in violation of those regulations.
3. If the tests were conducted in a manner unacceptable to the Department no decision will be made as to the compliance with emission standards. In such cases, the Department reserves the right to request that additional tests be performed by the company or to conduct its own tests. The company may still be found in violation of the requirement to demonstrate compliance by the deadlines in IAC 567-25.7(1)(b) or the appropriate permit.

## Steam Generators

### Steaming Rate

For purposes of compliance particulate testing of steam generators, the average steam production rate (as indicated by the steam flow integrator) for the three runs should equal or exceed the maximum continuous steaming rate at which the unit will be operated, as specified by the owner.

If the owner specified rating equals or exceeds the manufacturer's maximum continuous rating, testing at steaming rates down to 85 percent of that specified will be accepted, provided the emission rate at the specified rating is calculated according to the following equation:

$$y = xr^2$$

where: y = emission rate at the owner specified maximum steaming rate  
lbs/MMBtu

x = emission rate at the average tested steaming rate, lbs/MMBtu.

r = ratio of specified to tested steaming rate.

This equation was developed from Figure 7-21, page 74, Atmospheric Emissions from Coal Combustion, An Inventory Guide, 1966 (see Bibliography).

If the owner specified rating is less than the manufacturer's maximum continuous rating, testing at steaming rates less than that specified will be unacceptable, and additional testing may be required as discussed in the section "Source Operation and Necessary Production Rates", page IV-2.

### Heat Input

The heat input for a given boiler may be calculated using any of several techniques. There are four in common use. These are: (1) weighing the coal and obtaining samples for analysis, (2) measuring the steam and feed-water flow, temperature and pressure and assuming an operating efficiency based on the type of unit, the age, and the design efficiency, and (3) same as (2) except the efficiency is calculated using the ASME TEST FORM FOR ABBREVIATED EFFICIENCY TEST PTC 4.1-1964, pages 16-17, or its equivalent. In utilizing this method, an ultimate analysis on the fuel is preferred and it may be desirable to take ash samples.

Final acceptance of a test report will be subject to a reasonable boiler efficiency whether claimed or calculated as related to heat input. Although none of the methods described above is "above suspicion", the third is certainly to be preferred.

Rather than obtaining heat inputs, emission rates may be calculated using F-factors by the method cited in 40 C.F.R. 60.45(e) and in Appendix A, Method 19. This method is the reference method for sources subject to the New Source Performance Standards. The Department should be consulted before being used at other facilities.

### Coal Samples

When obtaining a coal sample, one should take a small sample every fifteen minutes to be combined, mixed and quartered into a single usable sample for the entire run after the run is completed. These samples must be sealed in airtight containers to allow for moisture analysis if needed. The size of the final sample may vary from two to fifty pounds

depending on the requirements of the laboratory doing the analysis. As a safeguard it is recommended that the samples be split, keeping one set of samples on site in case one set is lost.

In many cases where the boiler efficiency is accurately known or for sources other than boilers, a proximate analysis on each of the samples is adequate, but an ultimate analysis on two of the samples are adequate, with an ultimate analysis on the third. If the boiler efficiency is questionable, ultimate and proximate analyses should be made on all three samples.

#### Orsat Analysis

Since the importance of stack gas composition from a steam generator goes beyond the determination of molecular weight, the following sampling procedure is required.

- a. The stack gas shall be sampled at a minimum of 12 points simultaneously with particulate sampling.
- b. Sampling may be performed in three ways. The first is a "grab" sample direct to the analyzer. Second is a sample continuously integrated into a bag of suitable material. Third is to continuously analyze and record the flue gas using an oxygen analyzer instead of an Orsat. If sampling is continuous, small sampling rates should be used to avoid flow disturbance around the nozzle, and sampling at each point must be proportioned as described on page V-2.
- c. The sample should be withdrawn from the stack through a one-fourth to three-eighth inch diameter stainless steel tube placed alongside the pitot tube on the opposite side from the pitot tube. The end of the sampling tube should be one to one and one-half inches back from the centerline of the nozzle inlet.

- d. If grab samples are taken, they should be distributed over the entire test at approximately equal time intervals. The same applies to small integrated samples taken for less than 100% of the particulate sampling period.
- e. Grab sample averages must be weighted proportionately to the stack gas sampled at each respective point.
- f. When an integrated sample is obtained in a bag, three separate Orsat analyses should be performed on each bag sample. If individual readings for the same constituent vary by more than 0.2 percent, the Orsat and chemicals should be checked. The analyses should be performed within 30 minutes of completion of the run.
- g. Alteration of the particulate sampling train itself for direct withdrawal of stack gas for composition analysis is unacceptable.
- h. The use of a Fyrite gas analyzer may be acceptable when testing sources where very accurate analyses are not crucial, such as asphalt plants. However, prior approval must be given by the Department before this method is used.

### **Incinerators**

The methodology to be used for testing particulate emissions from incinerators is the same as that for any other type of source. The calculations are different in that the emission rate is adjusted to 12% CO<sub>2</sub>. For this reason, the sampling for O<sub>2</sub> and CO<sub>2</sub> must be performed with great accuracy. Unless an alternate method is approved by the Department prior to the test, only Orsat analysis or Reference Method 3A should be performed. The sample should be integrated over the entire test run as described in 40 CFR 60, Appendix A, Reference Method 3.

In the case where an incinerator uses a burner in addition to burning waste, a correction must be made for the CO<sub>2</sub> contributed by the fuel burned. The procedure for this is found in Appendix J of this manual as well as the Department's permit manual.

## **Sampling Procedure for Sulfur Dioxide**

As previously mentioned in the introduction, the acceptable methods for sulfur dioxide measurement are Reference Method 6, 6A, 6B, 6C - Determination of Sulfur Dioxide Emissions from Stationary Sources found in 40 C.F.R. Part 60, Appendix A. However, a discussion of the method and the differences between particulate and sulfur dioxide sampling are presented below. Testing for acid mist emissions from sulfuric acid plants should be conducted according to the procedures in 40 C.F.R. 60.85.

### **Preliminary Information**

The preliminary information required is the same as that required for a particulate test except that a velocity traverse just prior to sampling should be added to arrive at an average flow since sampling is done proportionally at only one point in the stack.\*

When sources are required to test for both particulates and sulfur dioxide emissions by the New Source Performance Standards, these tests may be combined as described in Reference Method 8 of Appendix A, 40 CFR. Part 60. This is not the case when the testing is to be performed to satisfy state requirements, however. Since the Iowa particulate test method requires the impinger contents of the train to be analyzed, sulfur dioxide sampling must be performed separately.

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\* The applicable subparts of the New Source Performance Standards may require sampling at more than one point.

### Preparation of the Sampling Train

The probe end should be packed with quartz or Pyrex glass wool, and the lining of the probe must be of heat resistant glass wrapped with a heating element to prevent condensation. The probe need not be marked since only one sampling point is used. If one adapts a sampling train normally used for particulates, a straight piece of glass tubing must be substituted for the glass fiber filter holder and the cyclone.

In sampling for sulfur dioxide, one may use a midget impinger train or the large impingers normally used in particulate sampling. If the midget impinger train is used, the first impinger should be a bubbler containing 15 ml of 80% (by volume) isopropanol and glass wool in the top. The second and third are simple impingers each containing 15 ml of 3% (by weight) hydrogen peroxide. The final impinger is usually left dry, but a small amount of moisture absorbent may be added if the moisture content of the stack gas is unusually high. Procedures for assembling the train and the leak check are the same as those for particulate sampling.

If the large impinger bottles are used, an alcohol impinger is not used, instead the first two impingers are charged with 100 ml of the peroxide solution. The rest of the sampling train is like the method 5 train with the exception that no filter is used. A number of testing options are available to the tester to use at his discretion. Reference Method 6 should be reviewed and the method to be used discussed with the Administrator.

### Sample Analysis

If the large impinger bottles were used, the sample should be placed in a graduated cylinder



and diluted with distilled water to a volume of 300 ml. Pipette 20 ml of the sample volume into an Erlenmeyer flask and add 80 ml isopropanol and two to four drops of thorin indicator. Titrate to a pink endpoint using 0.01 N barium perchlorate. A minimum of two titrations per run must be performed. Replicant titrations must agree within 1% or 0.2 ml, whichever is larger. A blank should be run with each series of samples, and the reagent should be standardized against 25 ml of standard sulfuric acid containing 100 ml of isopropanol.

If the midget impingers are used, dilute the sample with distilled water to 50 ml. Transfer 10 ml to an Erlenmeyer flask and add 40 ml isopropanol and two to four drops of thorin indicator. Titrate with 0.01 N barium perchlorate as above.

#### Audit Samples

Two EPA audit samples will be supplied by the Department to be analyzed simultaneously with the field samples. The results of these audit samples are then returned to the Department for evaluation. The preferred procedure is for the source tester to telephone the Department and report the results so an immediate evaluation can be made. Often the results are obtained on site, so the agency observer should be prepared to verify the results at that time.

When the results from the audit samples agree within the specified percentage of the actual concentration, no further requirements are made on the tester with the exception of including the audit results in the emission test report. Past audits indicate that the audit results will agree in most cases. However, when there is no agreement on the initial audit sample analysis, both the field samples and audit samples must be reanalyzed, and both the initial and reanalysis results must be included in the test report.

If the re-analyzed audit samples do not agree, the agency must decide whether to accept or reject the emission report. If the agreement criteria for the audit samples are met, the same enforcement agency may waive the auditing requirement provided that it has been less than 90 days from the last audit, and the same analytical personnel, reagents, and analytical system are used. The responsible enforcement agency can decide whether to grant a waiver of the audit for a 90-day period when the audit is conducted for a different agency.

### Calculations

The sample volume measured by the dry gas meter is corrected to standard conditions (70°F, 29.92 inches Hg.) using the following equation:

$$V_{ms} = (V_m) \left( \frac{T_{std.}}{T_m} \right) \left( \frac{P_b}{P_{std.}} \right) = 17.71 \left( \frac{V_m P_b}{T_m} \right)$$

Where:

$V_{ms}$  = volume of dry gas sampled at standard conditions.

$V_m$  = volume of dry gas sampled at meter conditions.

$T_{std.}$  = absolute temperature at standard conditions = 530°R

$T_m$  = average dry gas meter temperature, °R.

$P_b$  = barometric pressure at orifice meter, inches Hg.

$P_{std.}$  = absolute pressure at standard conditions = 29.92 inches Hg.

The sulfur dioxide concentration is calculated from the following equation:

$$C_{SO_2} = 7.05 \times 10^{-5} \frac{lb. - l}{g - ml} \left[ \frac{(V_t - V_{tb}) N (V_{sol.}/V_a)}{V_{ms}} \right]$$

Where:  $C_{SO_2}$  = concentration of sulfur dioxide at standard conditions, lb/SCF.  
 $7.05 \times 10^{-5}$  = conversion factor which includes 32 g/g-eq. sulfur dioxide, 4  
53.6 g/lb., and 1000 ml/l  
 $V_t$  = volume of barium perchlorate titrant used for the sample, ml.  
 $V_{tb}$  = volume of barium perchlorate titrant used for the blank, ml.  
 $\underline{N}$  = normality of barium perchlorate titrant, g'eq/l.  
 $V_{sol.}$  = total solution volume of sulfur dioxide = 50 ml for midget impingers,  
300 ml. for large impingers.  
 $V_a$  = volume of aliquot titrated = 10 ml for midget impingers, 20 ml for  
large impingers.  
 $V_{ms}$  = volume of dry gas sampled at standard conditions.

### The Test Report

The test report should contain essentially the same information required for particulate sampling test reports (see pages IV-1 and IV-2).

## **SYMBOLS AND ABBREVIATIONS**

acf	=	actual cubic feet
acfm	=	actual cubic feet per minute
atm.	=	atmosphere
B <sub>ws</sub>	=	volumetric fraction of water vapor in the stack gas
cf	=	cubic feet
cfm	=	cubic feet per minute
C	=	conversion constant, meter to stack conditions
C <sub>p</sub>	=	Pitot tube coefficient (0.84 +/- 0.02), dimensionless
CO	=	chemical formula for carbon monoxide
CO <sub>2</sub>	=	chemical formula for carbon dioxide
Δ	=	delta, signifies a change
d	=	distance from the inside face of a breaching wall to the center of the nearest test point
d <sub>d</sub>	=	equivalent diameters downstream from the nearest disturbance to the
d <sub>n</sub>	=	inside nozzle diameter, inches
d <sub>t</sub>	=	total number of equivalent diameters available
d <sub>u</sub>	=	equivalent diameters upstream from the nearest disturbance to the test port location
D	=	depth of rectangular breaching or stack, feet
D <sub>s</sub>	=	inside stack diameter, inches test port location.
°F	=	degrees Fahrenheit
ft	=	feet
ft <sup>3</sup>	=	cubic feet
g	=	grams

gr	=	grains
$\Delta H$	=	orifice pressure differential, inches water
$\Delta H_{@}$	=	orifice pressure differential at flow rate of 0.75 cfm at 70°F and 29.92 inches mercury
H <sub>2</sub> O	=	chemical formula for water
Hg	=	chemical symbol for mercury
in.	=	inches
K	=	orifice constant
K <sub>n</sub>	=	pivot point on nomograph for calculating $\Delta H$ as a function of $\Delta p$
lbs.	=	pounds
lb.-mole	=	the mass in pounds, of a chemical compound equal to its molecular weight
MW	=	molecular weight
M <sub>a</sub>	=	molecular weight of air = 29
M <sub>d</sub>	=	dry molecular weight
M <sub>w</sub>	=	wet molecular weight
m <sub>w</sub>	=	mass of water collected during a run, gms.
mg	=	milligrams
ml	=	milliliters
N	=	number of sampling points in a stack or breaching
N <sub>2</sub>	=	chemical symbol for nitrogen
n	=	the n <sup>th</sup> sampling point from the center of a round stack
n <sub>p</sub>	=	number of ports
O <sub>2</sub>	=	chemical symbol for oxygen
$\Delta p$	=	velocity pressure within a gas stream usually measured with a pitot tube

$P_a$	=	atmospheric pressure, inches of mercury
$P_b$	=	barometric pressure, inches of mercury
$P_m$	=	meter pressure, inches of mercury
$P_s$	=	total stack pressure, inches of mercury
$P_{sg}$	=	static gage pressure in stack, in. water
$Q$	=	gas flow rate, cfm.
$^{\circ}R$	=	degrees Rankin, = $^{\circ}F + 460$
$R_n$	=	distance from the center of a stack to the $n^{\text{th}}$ test point, numbered consecutively from the center
$r$	=	ratio of rated to tested steam load for steam generators
scf	=	standard cubic feet (at STP)
std	=	standard
STP	=	standard temperature and pressure, 70°F, 1 atmosphere
S-type	=	refers to Staussheibe pitot tube, also referred to as a Reversed type pitot tube
$\Sigma$	=	symbol for sum of
$\theta$	=	time, usually in minutes
$t$	=	time or temperature, °F
$t_1$	=	gas meter inlet temperature, °F
$t_2$	=	gas meter outlet temperature, °F
$t_d$	=	dry bulb temperature °F
$t_w$	=	wet bulb temperature, °F
$t_{wt}$	=	average wet test meter temperature °F
$T$	=	absolute temperature = $t + 460$ , °R
$T_m$	=	absolute meter temperature °R
$T_s$	=	absolute stack temperature °F
$V_1$	=	initial gas meter reading

## **APPENDIX A**

### **Source Operation Data Forms**

On the following pages, process and control equipment data sheets are included to illustrate some of the information required from the source owner. Although required information isn't necessarily limited to that illustrated, these data sheets with all applicable data filled in will generally suffice. Sources for which a specific operating data sheet has not been included should use the process weight sheet (page A-5). All sources tested are required to submit applicable control equipment information shown on page A-6.

**PARTICULATE EMISSIONS TEST REPORT  
STEAM GENERATOR OPERATING DATA**

Owner \_\_\_\_\_ Run No. \_\_\_\_\_

Unit No(s). \_\_\_\_\_ Date \_\_\_\_\_

Maximum Continuous Steam Prod'n (Manufacturer's Rating) \_\_\_\_\_ lbs/hr

Historical Average Steam Production \_\_\_\_\_ lbs/hr

Historical Maximum Steam Production \_\_\_\_\_ lbs/hr

Type and Source of Coals Normally Burned \_\_\_\_\_

Approximate Quantities of Each of Above Coals Burned Annually \_\_\_\_\_

Reinjection Capability: Yes \_\_\_\_\_ No \_\_\_\_\_

**BOILER DATA DURING RUN (AVERAGED)**

Steam Production (Integrator) \_\_\_\_\_ lbs/hr

Steam Pressure (Superheater Outlet) \_\_\_\_\_ psig

Steam Temperature (Superheater Outlet) \_\_\_\_\_ °F

Feedwater Flow (Integrator) \_\_\_\_\_ lbs/hr

Feedwater Temperature (From Deaerating Heater) \_\_\_\_\_ °F

Feedwater Temperature (Economizer Inlet) \_\_\_\_\_ °F

Feedwater Temperature (Economizer Outlet) \_\_\_\_\_ °F

Flue Gas Temperature (Economizer Inlet) \_\_\_\_\_ °F

Flue Gas Temperature (Economizer Outlet) \_\_\_\_\_ °F

Type and Source of Coal Burned During Run \_\_\_\_\_

Reinjection in Progress: Yes \_\_\_\_\_ No \_\_\_\_\_

Person Responsible for Data \_\_\_\_\_

Signature \_\_\_\_\_

Title/Position \_\_\_\_\_



**PARTICULATE EMISSIONS TEST REPORT  
CEMENT PLANT OPERATING DATA**

Owner \_\_\_\_\_ Run No. \_\_\_\_\_

Kiln No. \_\_\_\_\_ Date \_\_\_\_\_

Type of Kiln: \_\_\_\_\_ Wet \_\_\_\_\_ Dry

Kiln Diameter \_\_\_\_\_ ft.

Maximum Continuous Kiln Feed Rate (Manufacturer's Rating) \_\_\_\_\_ tons/hr.

Approximate Kiln Speed at Above Rating \_\_\_\_\_ rev./hr.

Historical Average Kiln Feed Rate \_\_\_\_\_ tons/hr.

Historical Maximum Kiln Feed Rate \_\_\_\_\_ tons/hr.

Insufflation Capability: Yes \_\_\_\_\_ No \_\_\_\_\_

Anticipated Fuel Usage: Coal \_\_\_\_\_ % of time.

Oil \_\_\_\_\_ % of time.

Gas \_\_\_\_\_ % of time.

Approximate Feed Composition During Test Limestone \_\_\_\_\_ %

Run by Weight Silica Clay \_\_\_\_\_ %

Alumina \_\_\_\_\_ %

Water (wet) \_\_\_\_\_ %

(Other) \_\_\_\_\_ %

Feed Size: \_\_\_\_\_ % passing \_\_\_\_\_ mesh sieve.

**KILN OPERATION DURING RUN (AVERAGED)**

Kiln Feed Rate \_\_\_\_\_ tons/hr.

Kiln Speed \_\_\_\_\_ RPH

Fuel \_\_\_\_\_ Coal \_\_\_\_\_ Oil \_\_\_\_\_ Gas \_\_\_\_\_

Insufflation in Progress: Yes \_\_\_\_\_ No \_\_\_\_\_

Person Responsible for Data \_\_\_\_\_

Signature \_\_\_\_\_

Title/Position \_\_\_\_\_

# PARTICULATE EMISSION TEST ASPHALT PLANT OPERATING DATA

Owner \_\_\_\_\_ Run No. \_\_\_\_\_  
Type of Mix \_\_\_\_\_ Date \_\_\_\_\_

Dryer Fuel \_\_\_\_\_  
Batch Size if Applicable \_\_\_\_\_ tons  
Manufacturer's Rated Asphalt Production Capacity \_\_\_\_\_ tons/hr.  
Historical Maximum Asphalt Production Rate \_\_\_\_\_ tons/hr.  
Historical Nominal Asphalt Production Rate \_\_\_\_\_ tons/hr.  
Nominal Asphalt Production Rate During Test Run \_\_\_\_\_ tons/hr.  
Method of Asphalt Production Rate Determination \_\_\_\_\_

Raw Materials Data: \_\_\_\_\_ % Limestone  
(During Test Run) \_\_\_\_\_ % Sand  
\_\_\_\_\_ % Gravel  
\_\_\_\_\_ % Moisture  
\_\_\_\_\_ % Asphalt  
\_\_\_\_\_ % Recycle  
\_\_\_\_\_ % (Other)

COLD FEED (During Test Run)

Raw Materials  
Washed (List)

<u>Size</u>	<u>% Passing</u>
1 1/2"	
1"	
1/2"	
3/8"	
Mesh # 4	
8	
16	
32	
50	
100	
200	

Person Responsible for Data: \_\_\_\_\_  
Signature: \_\_\_\_\_  
Title/Position: \_\_\_\_\_

**PARTICULATE EMISSION TEST**  
**OPERATING DATA\***  
(Type of Source)

**Owner:** \_\_\_\_\_

**Date:** \_\_\_\_\_

**Source:** \_\_\_\_\_

**Permit #:** \_\_\_\_\_

Maximum Continuous Process Rate: (Manufacturer's Rating) \_\_\_\_\_

Historical Average Process Rate: \_\_\_\_\_

Historical Maximum Process Rate: \_\_\_\_\_

Types and Sources (if any) of Fuels Normally Burned: \_\_\_\_\_

Type of Fuel Burned During Test: \_\_\_\_\_

Approximate Quantities of Fuels used Annually: \_\_\_\_\_

Recycling Capability: ☐ YES

☐ NO

Recycling in Progress ☐ YES

☐ NO

**Process Data During Runs**

**Process Rate wet\*\***  
(gal/hr, lb/hr, tons/hr, ect.)

**% Moisture**

**Process Rate dry\*\***  
(gal/hr, lb/hr, tons/hr, ect.)

**How Process Rate was  
Determined**

Run 1	Run 2	Run 3

**Person Responsible for Data** \_\_\_\_\_

**Signature:** \_\_\_\_\_

**Title/Position:** \_\_\_\_\_

\*\* Please indicate in the same units as the historical information

## AIR POLLUTION CONTROL EQUIPMENT OPERATING DATA \*

Plant \_\_\_\_\_  
Source Type \_\_\_\_\_  
Date \_\_\_\_\_ Time \_\_\_\_\_  
Air Flow Data \_\_\_\_\_

Location \_\_\_\_\_  
Rated Production \_\_\_\_\_  
Actual Production \_\_\_\_\_  
Run No. \_\_\_\_\_

### Mechanical Collector:

Tube Dia. \_\_\_\_\_ in. No. of Tubes \_\_\_\_\_. Design  $\Delta p$  in. H<sub>2</sub>O Gas Temp °F \_\_\_\_\_  
Observed  $\Delta p$  in H<sub>2</sub>O \_\_\_\_\_ Design cfm/tube @ Observed  $\Delta p$  \_\_\_\_\_ @ \_\_\_\_\_ °F.  
Fan Rated H.P. \_\_\_\_\_ Operating Volts \_\_\_\_\_ Operating Amps \_\_\_\_\_

### Electrostatic Precipitator

Field No.	Primary Voltage (volts)	Primary Current (amps)	Secondary Voltage (KV)	Secondary Current (ma)	Spark Rate (per min)

### Scrubber:

Type \_\_\_\_\_  $\Delta p$ (across scrubber) \_\_\_\_\_ in H<sub>2</sub>O  
Fan Rated HP \_\_\_\_\_ Operating Volts \_\_\_\_\_ Operating Amps \_\_\_\_\_  
Liquid Circulation Rate \_\_\_\_\_ gal/min. % Make-up \_\_\_\_\_ Blowdown \_\_\_\_\_ gpm  
Scrubbing Water Change Interval \_\_\_\_\_  
Settling Tank Cleaning Interval \_\_\_\_\_

### Baghouse:

Pressure-Positive \_\_\_\_\_ Negative \_\_\_\_\_ No. Compartments \_\_\_\_\_  
Type Cleaning \_\_\_\_\_ Clean Cycle \_\_\_\_\_  
Avg. Baghouse  $\Delta p$  \_\_\_\_\_ in H<sub>2</sub>O  $\Delta p$  Range \_\_\_\_\_  
Fan: Rated H.P. \_\_\_\_\_ Operating Volts \_\_\_\_\_ Operating Amps \_\_\_\_\_

### Cyclone:

Type \_\_\_\_\_  $\Delta p$  \_\_\_\_\_ in H<sub>2</sub>O Diameter \_\_\_\_\_  
Fan Rated HP \_\_\_\_\_ Operating Volts \_\_\_\_\_ Operating Amps \_\_\_\_\_

Person Responsible for Data \_\_\_\_\_

Signature \_\_\_\_\_

Title/Position \_\_\_\_\_

## **APPENDIX B**

### **Calibration of the Pitot Tube**

1. Calibration should be done in a breaching large enough so the blockage of air flow within it by the pitobe will not significantly affect the calibration results. A breaching having a cross-sectional area of at least four square feet is recommended.
2. Two holes in the side of the duct are required. The larger hole through which the Pitobe - including the "S" type pitot tube - is inserted is located downstream of the hole for the standard pitot tube so the tips of each respective pitot can be positioned in exactly the same point in the breaching. Because the pitot tubes are used one at a time to measure the velocity pressure it will be necessary to plug the hole not being used since infiltration will cause air flow disturbances.
3. The velocity pressure should be measured at the center of a straight run eight diameters downstream and two diameters upstream from any source of disturbance to the flow.
4. The calibration should be done for the expected range of velocity pressures, with a 3/8 inch nozzle attached to the pitobe.
5. There must be a minimum of one-half inch clearance between the pitot tube and the nozzle.
6. The 'S' type pitot tube should be calibrated twice, reversing the direction of its legs during the second calibration, each calibration consisting of three separate determinations.

7. Determine the pitot tube coefficient for each determination as:

$$C_p(S - type) = 0.99 \sqrt{\left( \frac{\Delta p (std)}{\Delta p (S - type)} \right)}$$

8. If sampling rates are to be set (as recommended in this manual) using a commercially available nomograph, one should use only those pitot tubes having a  $C_p$  equal to 0.85  $\pm$  0.02 since most such nomographs are designed for this  $C_p$ . (Other alternate methods of setting sampling rates are allowed as long as the time requirements discussed under The Sample Run section of this manual are met).
9. When alternatives to a nomograph are used for setting the sampling rate and other  $C_p$ 's can be utilized, calibration of the pitot tube should be done with the thermocouple in place.
10. Calibration of the pitot tube should be done once every six months. If visual inspection of a pitot tube indicates possible damage or misalignment, etc., it should be repaired and recalibrated prior to use.
11. As an alternative to biannual calibration, a value of 0.84 may be assumed if the pitotube has been constructed according to Method 2, Appendix A, as found in the latest edition of the Code of Federal Regulations. An inspection should be made before the start of each test to confirm that the measurements taken periodically have not changed.

## APPENDIX C

### Calibration of the Dry Gas Meter

1. The wet test meter\* should be a 1 cu. ft./revolution meter with a +/- 1% accuracy.
2. Warm up the meter box and wet the interior surfaces of the wet test meter by letting the pump run for 15 minutes at 0.5 in.  $\Delta H$ .
3. Adjust the bypass and needle valves to a flow rate of about 0.75 to 1.0 cfm.
4. Level the wet test meter and connect the outlet of the wet test meter to the inlet line of the sampling unit.
5. Record the initial reading on both flow meters.
6. Start the pump and allow the pump to run until ten or more cu. ft. have passed through the dry gas meter. During the test, the bypass valve may have to be adjusted to maintain ten inches of mercury vacuum.
7. Inlet and outlet temperatures for the dry gas meter and the temperature of the air entering the wet test meter (usually ambient temperature) should be recorded shortly after the start and shortly before the end of the test.
8. Turn the pump off and record the final volume readings on both meters.

\*Calibration of dry gas meters by local gas companies equipped for this purpose is acceptable provided a receipt for the certification is included in subsequent test reports and the gas meter is carefully reinstalled in the control box.

9. The calibration factor, y, is calculated as follows:

$$y = \frac{V_w P_b (t_d + 460)}{V_d (P_b + \frac{\Delta H}{13.6}) (t_{wt} + 460)}$$

where:  $V_w$  = gas volume, wet test meter, ft<sup>3</sup>.

$P_b$  = barometric pressure, in. Hg.

$t_d$  = average dry gas meter temperature, °F.

$V_d$  = gas volume, dry test meter, ft<sup>3</sup>.

$\Delta H$  = orifice pressure differential, in. H<sub>2</sub>O.

$t_{wt}$  = average wet test meter temperature °F.

10. This calibration factor must be applied to any volume measured during sampling. If it is greater than +/- 1%, the meter should be adjusted.
11. Calibration of the gas meter should be performed annually at the start of the "busy season", and checked weekly by comparison with the orifice.



## **Appendix D**

### **Calibration of the Orifice Meter**

The basis of the nomograph used with the sampling train is the value of  $\Delta H_{@}$  for the orifice.  $\Delta H_{@}$  is defined as the value of  $\Delta H$  measured under specific conditions. These conditions are a flow rate of 0.75 cfm of dry air (MW=29) at 70°F and 29.92 inches Hg.

The dry gas meter should be calibrated before the orifice meter is calibrated. Then using a stopwatch the following procedure can be used.

1. Level the manometer by leveling the meter box.
2. Zero the orifice leg of the manometer with the manometer disconnected from the orifice taps.
3. Allow the meter box to warm up by running the pump for a few minutes.
4. Connect the manometer to the orifice taps.
5. Adjust the coarse and fine adjust valves to get a reading of 0.5 inches of water in the orifice manometer leg ( $\Delta H$ ), and record the  $\Delta H$ .
6. Start the stopwatch at the same time the dry test meter volume ( $V_1$ ) is read. Record this volume and allow the dry test meter to measure a predetermined quantity of gas. The larger the quantity, the better the accuracy.
7. Record the inlet and outlet meter temperatures ( $t_1$  and  $t_2$ ) at regular time intervals during the run duration.
8. At the predetermined volume, stop the watch and record the dry test meter volume ( $V_2$ ) and the elapsed time ( $\theta$ )
9. Repeat steps 6 through 9, but adjust the  $\Delta H$  to 1.0, 2.0, and 6.0 inches of water on the orifice manometer.
10. Calibration of the orifice meter should be performed annually in conjunction with the gas meter.

## Calculations

1. Calculate Q, the flow rate, for each setting of  $\Delta H$  as follows:

$$Q = \frac{(V_2 - V_1)}{\theta} \left( \frac{(t_2 + 460)}{[(t_1 + t_2)/2] + 460} \right)$$

2. Calculate k for each setting of  $\Delta H$  as follows:

$$k = Q \sqrt{\frac{P_b * M_a}{T * \Delta H}}$$

where  $P_b$  = Barometric Pressure, inches Hg

$M_a$  = Molecular weight of air (29)

$T = t_2 + 460$

3. Calculate the average orifice constant, K

$$K = \frac{\sum k}{4}$$

4. Calculate  $\Delta H_{@}$  for the orifice as follows:

$$\Delta H_{@} = \frac{Q_a^2 * P_a * M_a}{K^2 * T_a}$$

$$\Delta H_{@} = \frac{Q_a^2 * P_a * M_a}{T_a} * \frac{1}{K^2}$$

$$\Delta H_{@} = \frac{(0.75) * (29.92) * (29)}{530} * \frac{1}{K^2}$$

$$\Delta H_{@} = 0.921 * \frac{1}{K^2}$$

Since the nomograph is designed for an  $\Delta H_{@}$  of 1.84 inches of water, a value with 0.25 inch of 1.84 is desirable. If a value in this range is not obtained, the orifice opening should be adjusted or the orifice replaced.

## **APPENDIX E**

### **Measurement of Nozzle Diameter**

1. Using a micrometer, measure the inside diameter of the nozzle to the nearest .001 inch.
2. Make five separate measurements using different diameters each time and calculate the average of those measurements.
3. The largest deviation from the average should not exceed 0.002 inch.
4. Nozzles should be inspected before each test for damage and measurements repeated as necessary.

## **APPENDIX F**

### **Nomograph Operation**

The correction factor nomograph (Figure 15, page F-3) and the operating nomograph (Figure 16, page F-4) are designed for use with the "EPA - Method 5" sampling train as aids for quickly adjusting sampling rate and for selecting a convenient nozzle size.

The following preliminary information is needed in order to determine the correction factor, C, in the nomograph:

1. Orifice calibration,  $\Delta H_{@}$ .
2. Actual meter temperature,  $T_m$ , °F (not absolute).
3. Percent moisture, %  $H_2O$ .
4. Stack pressure,  $P_s$ .
5. Meter pressure,  $P_m$ .

After the data has been collected, it is possible to obtain a correction factor by the following procedure:

1. Draw a line from  $\Delta H_{@}$  to  $T_m$  to obtain point "A" on reference line 1.
2. Draw a line from point "A" to %  $H_2O$  to obtain point "B" on reference line 2.
3. Draw a line from point "B" to the calculated value of  $P_s/P_m$  to obtain the correction factor C.

The following information is needed in order to size the nozzle and set the operating nomograph:

1. Correction factor C.
2. Actual stack temperature,  $T_s$ , °F (not absolute).
3. Average velocity pressure,  $\Delta p$ , in.  $H_2O$ .
4. Exact available nozzle sizes, d, in.

In order to select the nozzle size and to set the  $K_n$  factor pivot point, the following procedure should be used:

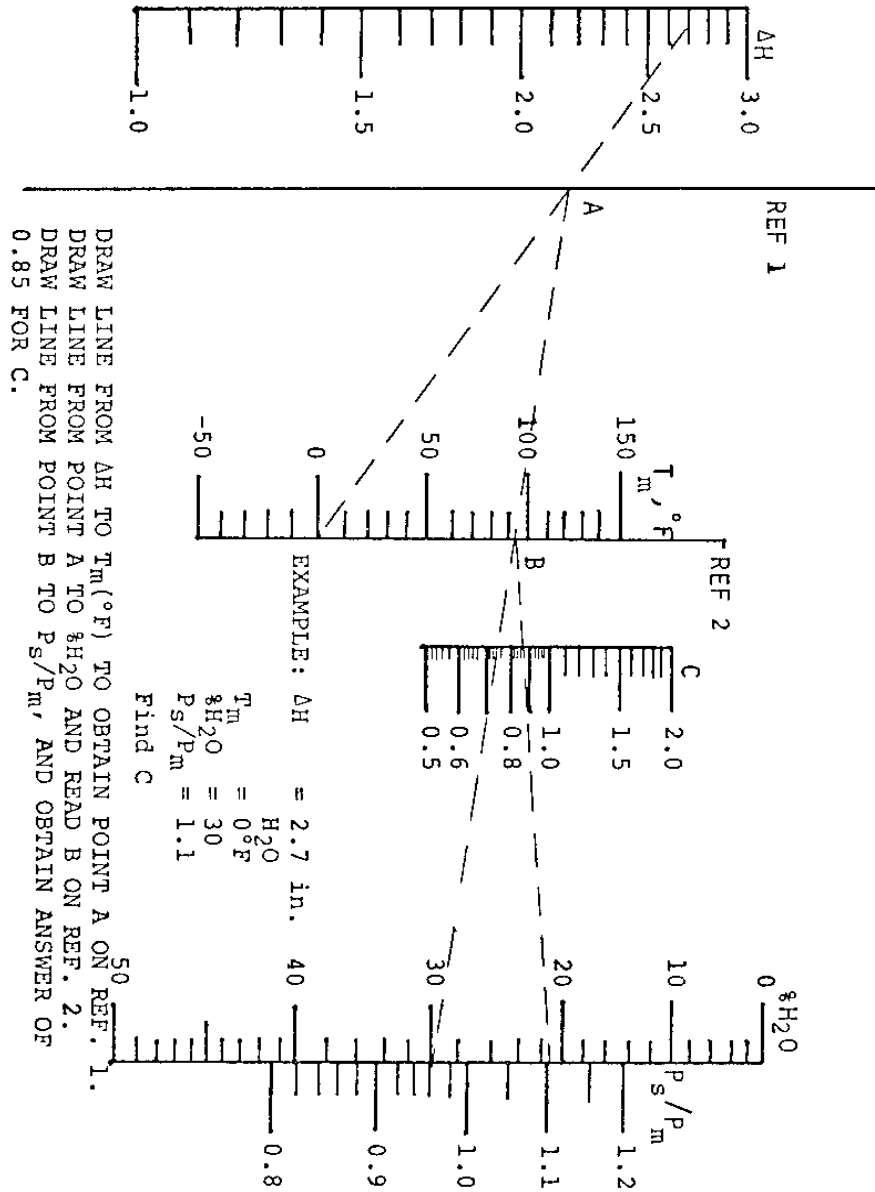
1. Align the correction factor,  $C$ , on the sliding scale with the reference mark, "A".
2. Align  $T_s$  with the average  $\Delta p$ , note the probe tip diameter on the  $D$  scale, and select the exact nozzle size closest to it.
3. Align  $T_s$  with the exact nozzle size selected and obtain a value on the  $\Delta p$  scale. (Reference  $\Delta p$ ).
4. Align the  $\Delta p$  value with the reference mark, "B", on the  $\Delta H$  scale, and set the  $K_n$  factor pivot point by tightening down the thumb screw.

The nomograph assumes the following once the  $K$  factor pivot point is set:

1.  $T_s$  does not change from the assumed  $T_s$  by more than 5% of the absolute stack temperature.
2.  $d$  is not changed during the test.
3.  $T_m$  was estimated correctly and does not vary much more than  $10^\circ\text{F}$ .
4. Percent  $\text{H}_2\text{O}$  remains constant, within  $\pm 10\%$ .
5.  $P_s$  and  $P_m$  remain constant, within  $\pm 1.0\%$ .
6.  $C_p = 0.85 \pm 0.02$ .

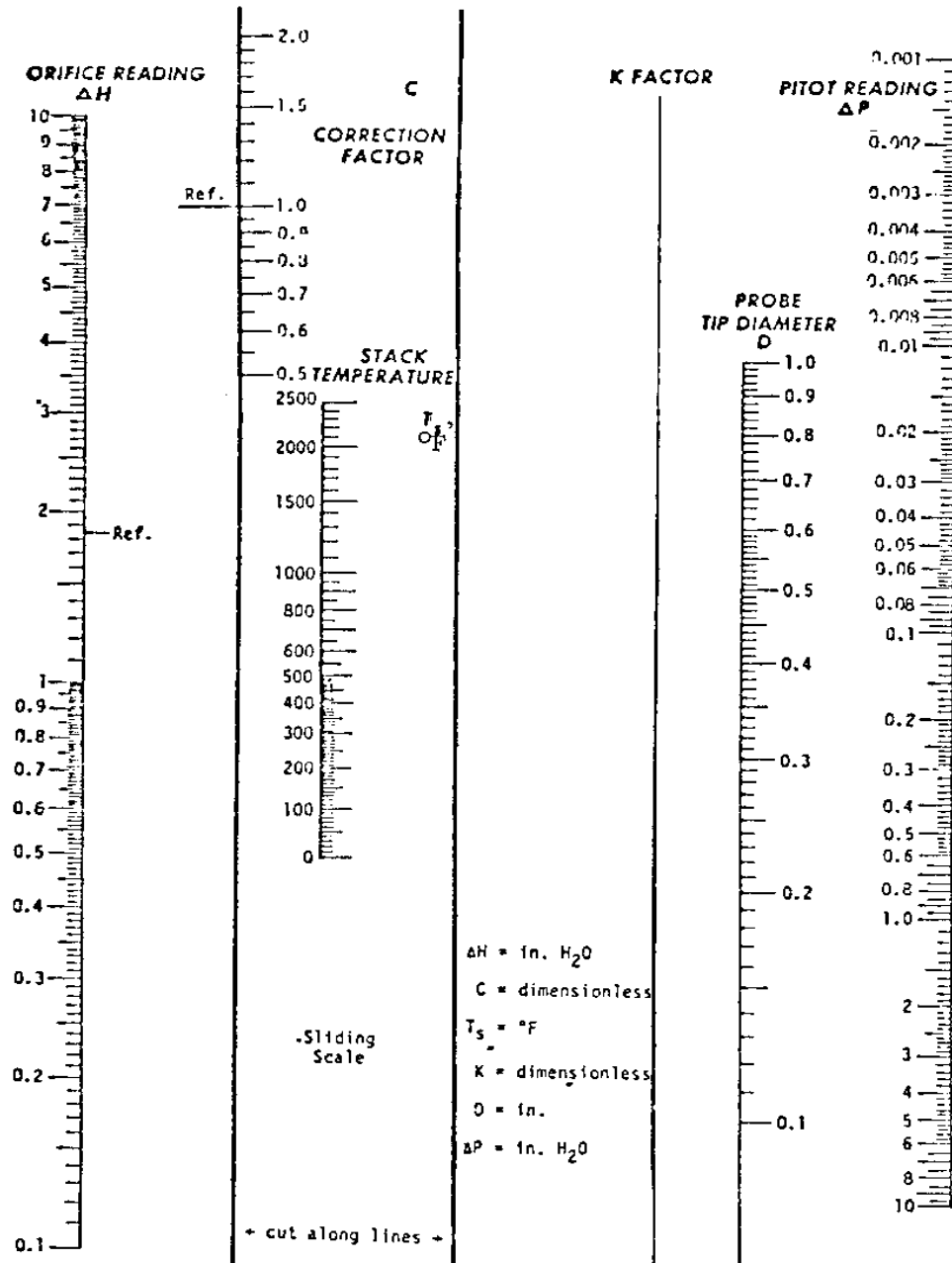
During the test  $\Delta p$  is read for each point and the corresponding  $\Delta H$  for the orifice is obtained using the nomograph.

Figure 7



NOMOGRAPH FOR C-FACTOR DETERMINATION

Figure 8



OPERATING NOMOGRAPH



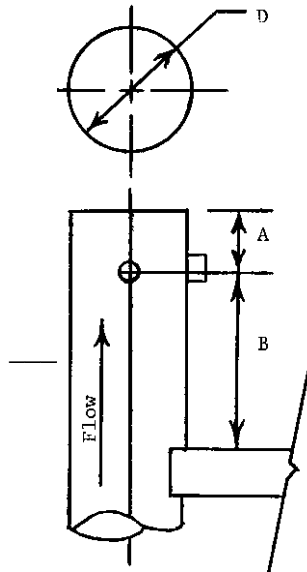
## **APPENDIX G**

### **Data Sheets and Calculations**

On the following pages, data and calculation sheets used by this Department are displayed. These sheets are included only as a guide and are not intended for mandatory usage. However, adoption of these data sheets for compliance tests would aid in their evaluation by the Air Quality Section.

## Port Locations

Plant \_\_\_\_\_ Test No. \_\_\_\_\_  
 Source \_\_\_\_\_ Date \_\_\_\_\_



A = \_\_\_\_\_ ft.

B = \_\_\_\_\_ ft.

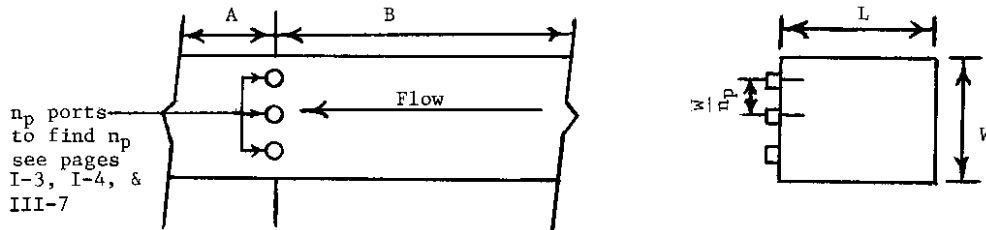
D = \_\_\_\_\_ ft.

Eq. diameters upstream =  $A \div D$   
 = \_\_\_\_\_  $\div$  \_\_\_\_\_  
 = \_\_\_\_\_

Eq. diameters downstream =  $B \div D$   
 = \_\_\_\_\_  $\div$  \_\_\_\_\_  
 = \_\_\_\_\_

Total No. of points = \_\_\_\_\_ (N)

$n_p$  ports. To find  $n_p$ , see pages I-3 & I-4



W = \_\_\_\_\_ ft.

L = \_\_\_\_\_ ft.

$$D = 2x \frac{LxW}{L+W}$$

Eq. diameters upstream =  $A \div D$  = \_\_\_\_\_  $\div$  \_\_\_\_\_ = \_\_\_\_\_ ft.

Eq. diameters downstream =  $B \div D$  = \_\_\_\_\_  $\div$  \_\_\_\_\_ = \_\_\_\_\_ ft.

Total No. of points = \_\_\_\_\_ (N)

**Percent Moisture Estimation**  
(optional-preliminary)

Run No. \_\_\_\_\_

Plant \_\_\_\_\_  
Source \_\_\_\_\_

Sheet \_\_\_\_\_ of \_\_\_\_\_  
Date \_\_\_\_\_  
Calculated by \_\_\_\_\_

Impinger #1

Totals

Final Volume \_\_\_\_\_  
Initial Volume \_\_\_\_\_  
\_\_\_\_\_ ..... ml.

Impinger #2

Final Volume \_\_\_\_\_  
Initial Volume \_\_\_\_\_  
\_\_\_\_\_ ..... ml.

Impinger #3

Final Volume \_\_\_\_\_  
Initial Volume \_\_\_\_\_  
\_\_\_\_\_ ..... ml.

Impinger #4

Tare Weight \_\_\_\_\_  
Drierite \_\_\_\_\_  
Initial Weight \_\_\_\_\_  
Final Weight \_\_\_\_\_  
\_\_\_\_\_ ..... g.

Cyclone Flask

Volume Collected \_\_\_\_\_ ..... ml.

Total = \_\_\_\_\_ ml.

$$\begin{aligned} V_{ws} &= 0.0474 \times V_{wc} \text{ (ml.)} \\ &= 0.0474 \times \text{_____} \\ &= \text{_____} \text{ cf. @ STP} \end{aligned}$$

$$\begin{aligned} B_{wo} &= \frac{V_{ws}}{V_{ws} + V_m} \\ &= \frac{(\text{_____})}{(\text{_____}) + (\text{_____})} \end{aligned}$$

$$\begin{aligned} \% \text{ moisture} &= B_{wo} \times 100\% \\ &= (\text{_____}) \times 100\% \\ &= \text{_____} \% \end{aligned}$$

$B_{wo}$  = fraction water vapor in exit gas

$V_m$  = total dry gas metered at metered conditions, ft<sup>3</sup>

$V_{ws}$  = volume of water at STP (vapor), ft<sup>3</sup>

ml = milliliter

$V_{wc}$  = volume water condensed (liquid), (liquid), ml.

Filter No. \_\_\_\_\_

Est. Ave $T_s$ , °F	Nozzle Diam, in.	Ref $\Delta p$	Ambient Temp.	Min/Point
100	0.075	0.000	70	10
100	0.075	0.000	70	20
100	0.075	0.000	70	30
100	0.075	0.000	70	40
100	0.075	0.000	70	50
100	0.075	0.000	70	60
100	0.075	0.000	70	70
100	0.075	0.000	70	80
100	0.075	0.000	70	90
100	0.075	0.000	70	100
100	0.075	0.000	70	110
100	0.075	0.000	70	120
100	0.075	0.000	70	130
100	0.075	0.000	70	140
100	0.075	0.000	70	150
100	0.075	0.000	70	160
100	0.075	0.000	70	170
100	0.075	0.000	70	180
100	0.075	0.000	70	190
100	0.075	0.000	70	200
100	0.075	0.000	70	210
100	0.075	0.000	70	220
100	0.075	0.000	70	230
100	0.075	0.000	70	240
100	0.075	0.000	70	250
100	0.075	0.000	70	260
100	0.075	0.000	70	270
100	0.075	0.000	70	280
100	0.075	0.000	70	290
100	0.075	0.000	70	300
100	0.075	0.000	70	310
100	0.075	0.000	70	320
100	0.075	0.000	70	330
100	0.075	0.000	70	340
100	0.075	0.000	70	350
100	0.075	0.000	70	360
100	0.075	0.000	70	370
100	0.075	0.000	70	380
100	0.075	0.000	70	390
100	0.075	0.000	70	400
100	0.075	0.000	70	410
100	0.075	0.000	70	420
100	0.075	0.000	70	430
100	0.075	0.000	70	440
100	0.075	0.000	70	450
100	0.075	0.000	70	460
100	0.075	0.000	70	470
100	0.075	0.000	70	480
100	0.075	0.000	70	490
100	0.075	0.000	70	500
100	0.075	0.000	70	510
100	0.075	0.000	70	520
100	0.075	0.000	70	530
100	0.075	0.000	70	540
100	0.075	0.000	70	550
100	0.075	0.000	70	560
100	0.075	0.000	70	570
100	0.075	0.000	70	580
100	0.075	0.000	70	590
100	0.075	0.000	70	600
100	0.075	0.000	70	610
100	0.075	0.000	70	620
100	0.075	0.000	70	630
100	0.075	0.000	70	640
100	0.075	0.000	70	650
100	0.075	0.000	70	660
100	0.075	0.000	70	670
100	0.075	0.000	70	680
100	0.075	0.000	70	690
100	0.075	0.000	70	700
100	0.075	0.000	70	710
100	0.075	0.000	70	720
100	0.075	0.000	70	730
10				

Imp. Box #  
Date  
P<sub>b</sub>  
Pitot C<sub>p</sub>  
Meter  $\Delta H_{@}$   
Estimated T<sub>m</sub>  
Est. % Moisture  
Static Duct Pressure  
C-Factor  
Leak Tests: Before

[illegible]G4

Run No. \_\_\_\_\_  
 Filter No. \_\_\_\_\_

# **Condensible and Stack Gas Volume Calculations** Sheet A

Plant \_\_\_\_\_ Sheet \_\_\_\_\_ of \_\_\_\_\_  
 Source \_\_\_\_\_ Date \_\_\_\_\_  
 Calculated by \_\_\_\_\_

	<u>Impinger #1</u>	<u>Impinger #2</u>	<u>Impinger #3</u>	<u>Impinger #4</u>	<u>Cyclone Catch</u>
Final Volume					
(Weight)					
Initial Volume					
(Weight)					
Volume (Weight)					
Collected					

$V_m =$  \_\_\_\_\_ cu. ft. Total \_\_\_\_\_

$P_m = P_b + H/13.6 =$  \_\_\_\_\_  $+ \frac{\text{_____}}{13.6} =$  \_\_\_\_\_ in. Hg.

$T_m = t_m + 460 =$  \_\_\_\_\_  $+ 460 =$  \_\_\_\_\_ °R

$V_{ms} = \frac{17.7 \times V_m \times P_m}{T_m} = \frac{17.7 ( \text{ } ) ( \text{ } )}{( \text{ } )} =$  \_\_\_\_\_ c.f. @ STP

$V_{ws} = 0.0474 \times V_{wc}(ml) = (0.0474) ( \text{ } ) =$  \_\_\_\_\_ c.f. @ STP

$B_{wo} = \frac{V_{ws}}{V_{ws} + V_{ms}}$   
 $= \frac{( \text{ } )}{( \text{ } ) + ( \text{ } )}$   
 $=$  \_\_\_\_\_

**% moisture =  $B_{wo} \times 100\% = ( \text{ } ) (100\%) =$  \_\_\_\_\_ %**

$B_{wo}$  = Fraction water vapor in exit gas  
 $P_b$  = Barometric pressure in. Hg.  
 $P_m$  = Pressure @ gas meter in. Hg.  
 STP = Standard temp. and pressure =  
 70°F, 29.92 in. Hg.  
 $t_m$  = Average meter temp., °F

$T_m$  = Average meter temp., °R  
 $V_m$  = Total dry gas metered at meter cond. ft<sup>3</sup>  
 $V_{ms}$  = Total dry gas metered at STP, ft<sup>3</sup>  
 $V_{wc}$  = Volume water condensed (liquid), ml.  
 $V_{ws}$  = Volume of water at STP (vapor), ft<sup>3</sup>

Run No. \_\_\_\_\_  
Filter No. \_\_\_\_\_

**Condensible and Stack Gas Volume Calculations**  
Sheet B

Plant \_\_\_\_\_ Sheet \_\_\_\_\_ of \_\_\_\_\_  
Source \_\_\_\_\_ Date \_\_\_\_\_  
Calculated by \_\_\_\_\_

From preceding page:

$$V_m = \text{_____ ft}^3, P_m = \text{_____ in. Hg.}, T_m = \text{_____ } ^\circ\text{R}, B_{wo} = \text{_____}$$

$$T_s = t_s + 460 = \text{_____} + 460 = \text{_____ } ^\circ\text{R}$$

$$P_s = P_b + P_{sg}/13.6 = \text{_____} + \text{_____}/13.6 = \text{_____ in. Hg.}$$

$$V_{Tn} = CV_m$$

$$\text{where } C = (T_s)(P_m) / (T_m)(P_s)(1 - B_{wo})$$

$$C = (\text{_____})(\text{_____}) / (\text{_____})(\text{_____})(\text{_____})$$

$$C = \text{_____}$$

$$V_{Tn} = CV_m$$

$$= (\text{_____})(\text{_____})$$

$$= \text{_____ acf}$$

$$M_d = 0.44 (\%CO_2) + 0.32 (\%O_2) + 0.28 (\%N_2 + \%CO)$$

$$= 0.44 (\text{_____}) + 0.32 (\text{_____}) + 0.28 (\text{_____} + \text{_____})$$

$$= \text{_____} + \text{_____} + \text{_____}$$

$$= \text{_____}$$

$$M_w = (M_d)(1 - B_{wo}) + 18 B_{wo}$$

$$= (\text{_____})(\text{_____}) + 18 (\text{_____})$$

$$= \text{_____}$$

$$A_s = (\text{rectangular}) = \text{Width (ft.)} \times \text{Depth (ft.)} = (\text{_____})(\text{_____}) = \text{_____ ft}^2$$

$$A_s = 0.0054541 D_s^2 = 0.0054541 (\text{_____})^2 = \text{_____ ft}^2$$

$$A_n = 0.0054541 d_n^2 = 0.0054541 (\text{_____})^2 = \text{_____ ft}^2$$

$$A_s/A_n = \text{_____} / \text{_____} = \text{_____}$$

$$Q_s = u_s A_s (60) = (\text{_____})(\text{_____})(60) = \text{_____ acfm}$$

$A_n$  = Area nozzle

$A_s$  = Area stack

$B_{wo}$  = Fraction water vapor in exit gas

$c$  = Conversion constant, meter to stack conditions

$d_n$  = Internal nozzle diameter, inches

$D_s$  = Internal stack diameter, inches

$^{\circ}\text{F}$  = Degrees Fahrenheit

$_H$  = Avg. orifice press. drop., in.  $H_2O$

$M_d$  = Molecular weight - dry basis

$V_{Tn}$  = Total volume exit gas pulled through nozzle

$P_b$  = Barometric press. in. Hg.

$P_m$  = Pressure at gas meter, in. Hg.

$P_{sg}$  = Static press. in stack, in  $H_2O$

$P_s$  = Absolute stack Press., in. Hg.

$Q_s$  = Gas flow up stack, acfm

STP = Standard Temperature and pressure  
(70°F, 29.92 in. Hg.)

$^{\circ}\text{R}$  = Degrees Rankine

$t_s$  = Average stack temp., °F

$T_s$  = Average stack temp. °R

$V_m$  = Total dry gas metered at meter cond.

Filter No. \_\_\_\_\_

Plant \_\_\_\_\_  
Source \_\_\_\_\_

Date \_\_\_\_\_

Calculated by \_\_\_\_\_

[illegible]

$$u_s = 85.49 * C_p * \sqrt{\frac{T_s * \Delta p_s}{P_s * M_w}}$$

Wet cf = (cf @ meter con)\*(C), C is a constant determined on the "Stack Gas Volume Calculations" sheet

# Appendix H

## CHAPTER 25 MEASUREMENT OF EMISSIONS

[Prior to 7/1/83, DEQ Ch 7]

[Prior to 12/3/86, Water, Air and Waste Management[900]]

### **567—25.1(455B) Testing and sampling of new and existing equipment.**

**25.1(1)** *Continuous monitoring of opacity from coal-fired steam generating units.* The owner or operator of any coal-fired or coal-gas-fired steam generating unit with a rated capacity of greater than 250 million Btus per hour heat input shall install, calibrate, maintain, and operate continuous monitoring equipment to monitor opacity. If an exhaust services more than one steam generating unit as defined in the preceding sentence, the owner has the option of installing opacity monitoring equipment on each unit or on the common stack. Such monitoring equipment shall conform to performance specifications

specified in 25.1(9) and shall be operational within 18 months of the date these rules become effective. The director may require the owner or operator of any coal-fired or coal-gas-fired steam generating unit to install, calibrate, maintain and operate continuous monitoring equipment to monitor opacity whenever the compliance status, history of operations, ambient air quality in the vicinity surrounding

the generator or the type of control equipment utilized would warrant such monitoring.

**25.1(2)** Reserved.

**25.1(3)** Reserved.

**25.1(4)** *Continuous monitoring of sulfur dioxide from sulfuric acid plants.* The owner or operator of any sulfuric acid plant of greater than 300 tons per day production capacity, the production being expressed as 100 percent acid, shall install, calibrate, maintain and operate continuous monitoring equipment to monitor sulfur dioxide emissions. Said monitoring equipment shall conform to the minimum performance specifications specified in 25.1(9) and shall be operational within 18 months of the date these rules become effective.

**25.1(5)** *Maintenance of records of continuous monitors.* The owner or operator of any facility which is required by any of 25.1(1) to 25.1(4) to install, calibrate, maintain and operate continuous monitoring equipment shall maintain, for a minimum of two years, a file of all information pertinent to each monitoring system present at the facility. Such information must include but is not limited to all emissions data (raw data, adjusted data, and any or all adjusted factors used to convert emissions from units of measurement to units of the applicable standard), performance evaluations, calibrations and zero checks, and records of all malfunctions of monitoring equipment or source and repair procedures performed.

**25.1(6)** *Reporting of continuous monitoring information.* The owner or operator of any source affected by 25.1(1) to 25.1(4) shall provide quarterly reports to the director, no later than 30 calendar days following the end of the calendar quarter, on forms provided by the director. All periods of recorded emissions in excess of the applicable standards, the results of all calibrations and zero checks and performance evaluations occurring during the reporting period, and any periods of monitoring equipment malfunctions or source upsets and any apparent reasons for these malfunctions and upsets shall be included in the report.

**25.1(7)** *Tests by owner.* The owner of new or existing equipment or the owner's authorized agent shall conduct emission tests to determine compliance with applicable rules in accordance with these requirements.

*a. General.* The owner of new or existing equipment or the owner's authorized agent shall notify the director in writing, not less than 30 days before a required test or performance evaluation of a continuous

emission monitor is performed to determine compliance with applicable requirements of 567—Chapter 23 or a permit condition. For the department to consider test results a valid demonstration of compliance with applicable rules or a permit condition, such notice shall be given. Such notice shall include the time, the place, the name of the person who will conduct the tests and other information as required by the department. Unless specifically waived by the department, a pretest meeting



shall be held not later than 15 days prior to conducting the compliance demonstration. The department may accept a testing protocol in lieu of the pretest meeting. A representative of the department shall be permitted to witness the tests. Results of the tests shall be submitted in writing to the director in the form of a comprehensive report within six weeks of the completion of the testing.

*b. New equipment.* Unless otherwise specified by the department, all new equipment shall be tested by the owner or the owner's authorized agent to determine compliance with applicable emission limits. Tests conducted to demonstrate compliance with the requirements of the rules or a permit shall be conducted within 60 days of achieving maximum production but no later than 180 days of startup, unless a shorter time frame is specified in the permit.

*c. Existing equipment.* The director may require the owner or the owner's authorized agent to conduct an emission test on any equipment if the director has reason to believe that the equipment does not comply with applicable requirements. Grounds for requiring such a demonstration of compliance include a modification of control or process equipment, age of equipment, or observation of opacities or other parameters outside the range of those indicative of properly maintained and operated equipment. Testing may be required as necessary to determine actual emissions from a source where that source is believed to have a significant impact on the public health or ambient air quality of an area. The director shall provide the owner or agent not less than 30 days to perform the compliance demonstration

and shall provide written notice of the requirement.

**25.1(8) Tests by department.** Representatives of the department may conduct separate and additional air contaminant emission tests and continuous monitor performance tests of an installation on behalf of the state and at the expense of the state. Sampling holes, safe scaffolding and pertinent allied facilities, but not instruments or sensing devices, as needed, shall be requested in writing by the director and shall be provided by and at the expense of the owner of the installation at such points as specified in the request. The owner shall provide a suitable power source to the point or points of testing so that sampling instruments

can be operated as required. Analytical results shall be furnished to the owner.

**25.1(9) Methods and procedures.** Stack sampling and associated analytical methods used to evaluate compliance with emission limitations of 567—Chapter 23 or a permit condition are those specified in the "Compliance Sampling Manual\*" adopted by the commission on May 19, 1977, as revised through March 14, 2001. Sampling methods, analytical determinations, minimum performance specifications

and quality assurance procedures for performance evaluations of continuous monitoring systems are those found in Appendices A (as amended through March 12, 1996), B (as amended through December 15, 1994) and F (as amended through February 11, 1991) of 40 CFR Part 60, and Appendices A (as amended through May 22, 1996), B (as amended through May 17, 1995), and H (as amended through July 30, 1993) of 40 CFR Part 75.

**25.1(10) Exemptions from continuous monitoring requirements.** The owner or operator of any source affected by 25.1(1) to 25.1(4) is exempt if it can be demonstrated that any of the conditions set forth in this subrule are met with the provision that periodic recertification of the existence of these conditions can be requested.

*a.* An affected source is subject to a new source performance standard promulgated in 40 CFR Part 60 as amended through November 24, 1998.

\*Available from department.

*b.* An affected steam generator had an annual capacity factor for calendar year 1974, as reported to the Federal Power Commission, of less than 30 percent or the projected use of the unit indicates the annual capacity factor will not be increased above 30 percent in the future.

*c.* An affected steam generator is scheduled to be retired from service within five years of the date these rules become effective.

*d.* Rescinded IAB 1/20/93, effective 2/24/93.

*e.* The director may provide a temporary exemption from the monitoring and reporting requirements during any period of monitoring system malfunction, provided that the source owner or operator shows, to the satisfaction of the director, that the malfunction was unavoidable and is being repaired as expeditiously as practical.

**25.1(11) Extensions.** The owner or operator of any source affected by 25.1(1) to 25.1(4) may request an extension of time provided for installation of the required monitor by demonstrating to the

director that good faith efforts have been made to obtain and install the monitor in the prescribed time.

**25.1(12) Continuous monitoring of sulfur dioxide from emission points involved in an alternative emission control program.** The owner or operator of any facility applying for an alternative emission control program under 567—subrule 567—22.7(1) that involves the trade-off of sulfur dioxide emissions shall install, calibrate, maintain and operate continuous sulfur dioxide monitoring equipment consistent with EPA reference methods (40 CFR Part 60, Appendix B, as amended through December 15, 1994). The equipment shall be operational within three months of EPA approval of an alternative emission control program.

**567—25.2(455B) Continuous emission monitoring under the acid rain program.** The continuous emission monitoring requirements for affected units under the acid rain program as provided in 40 CFR 75 as adopted January 11, 1993, and as corrected or amended through October 24, 1997, are adopted by reference.

These rules are intended to implement Iowa Code section 455B.133.

[Filed 8/24/70; amended 12/11/73, 12/17/74]

[Filed 5/27/77, Notices 8/9/76, 12/29/76—published 6/15/77, effective 7/20/77]

[Filed 9/26/80, Notice 5/28/80—published 10/15/80, effective 11/19/80]

[Filed emergency 6/3/83—published 6/22/83, effective 7/1/83]

[Filed emergency 11/14/86—published 12/3/86, effective 12/3/86]

[Filed 12/30/92, Notice 9/16/92—published 1/20/93, effective 2/24/93]

[Filed 2/25/94, Notice 10/13/93—published 3/16/94, effective 4/20/94]

[Filed 5/19/95, Notice 3/15/95—published 6/7/95, effective 7/12/95]

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[Filed 10/30/98, Notice 8/26/98—published 11/18/98, effective 12/23/98]

[Filed 5/28/99, Notice 3/10/99—published 6/16/99, effective 7/21/99]

[Filed 1/19/01, Notice 6/14/00—published 2/7/01, effective 3/14/01]

## APPENDIX I

### Stack Sampling Method Impinger Workup

As outlined in the Compliance Sampling Manual of the State of Iowa, the contents of the Impinger Section of the particulate sampling train are to be analyzed for organic condensibles with subsequent evaporation of the water and other volatiles. Any residues resulting from the outlined procedure meet the definition of particulate as given in subrule 20.2, "any material, except uncombined water, that exists in a finely divided form as a liquid or solid at standard conditions". Standard conditions are further defined as, "a gas temperature of 70°F and a gas pressure of 29.92 inches of mercury absolute". These residues must therefore be reported as particulate and included as stack emissions in the results of the test report since they fit this definition.

When dealing with this subject, one must first consider that ambient air quality standards have been set. Emission standards were then calculated via modeling techniques which, when met, will allow the ambient standards to be achieved and maintained. These emission standards are a function of a number of variables among which are background particulate levels, meteorological conditions, and what one chooses to call emissions. In the case of particulate, the latter depends on one's definition of particulate matter.

Therefore, in keeping with the implementation plan of the State of Iowa to achieve required ambient air quality standards, the impinger catch must be included as particulate since it meets the definition. The inclusion of the wet catch has not cast any undue hardship to industry since this part of the catch is usually small. It has been the observation of the writer that where the impinger catch was significant, the appearance of the stack indicated an excessive particulate emission rate.

With regard to the changes the Environmental Protection Agency made in the December 23, 1971, Federal Register, the 3rd Paragraph on page 24876 reads as follows:

"Particulate matter performance testing procedures have been revised to eliminate the requirement for impingers in the sampling train. Compliance will be based only on material collected in the dry filter. Emission limits have been adjusted as appropriate to reflect the change in the test methods. The adjusted standards require the same degree of particulate control as the originally proposed standards."

As an example of the significance of the third sentence in the above paragraph, the New Performance Standard for Steam Generators was changed from 0.2 pounds per million BTU input to 0.1 pound per million BTU input when the federal test method was revised to exclude the impinger catch.

If the State of Iowa were to follow this precedent, the allowable in our Rules and Regulations would necessarily be proportionately reduced if the impinger catch were dropped. In light of the above discussion, this would have the effect of stiffening our Regulations since, at the level of our present allowables, the impinger catch should be a relatively small percentage of the total particulate emissions.

## Appendix J

### CO<sub>2</sub> Adjustment for Incinerator Data

A baseline for the stack is established from a gas sample taken when nothing is in the incinerator, this is the burner only sample. This is compared to a gas sample taken when waste is in the incinerator, waste and burner sample. EPA methods 1, 2, and 3 are required for the purpose of finding the stack gas velocity and molecular weight. EPA method 4 is required for the waste and burner runs, but a wet bulb/dry bulb with a psychrometric chart may be used during the burner only sample to find the stack gas moisture. The stack's emissions are adjusted as follows:

#### Orsat Analysis-Burner Only (From Bag Sample)

Sampling Point Location \_\_\_\_\_  
 Date \_\_\_\_\_ Time \_\_\_\_\_

	Analysis 1	Analysis 2	Analysis 3	Average	Molecular Weight	weight/mol (dry)
%CO <sub>2</sub> (dry)					x 44/100	
%CO (dry)					x 28/100	
%O <sub>2</sub> (dry)					x 32/100	
%N <sub>2</sub> (dry)					x 28/100	
Md =Average molecular weight of dry stack gas =						sum of column

#### Orsat Analysis-Waste and Burners (From Bag Sample)

Sampling Point Location \_\_\_\_\_  
 Date \_\_\_\_\_ Time \_\_\_\_\_

	Analysis 1	Analysis 2	Analysis 3	Average	Molecular Weight	weight/mol (dry)
%CO <sub>2</sub> (dry)					x 44/100	
%CO (dry)					x 28/100	
%O <sub>2</sub> (dry)					x 32/100	
%N <sub>2</sub> (dry)					x 28/100	
Md =Average molecular weight of dry stack gas =						sum of column

## CO<sub>2</sub> Adjustment for Incinerator Data

### Velocity Traverse and Calculations (Burner Only)

Stack Temp	$T_s = t_s + 460$	= _____ °R
Moisture in Stack Gas	$B_{ws}$	= _____ %
Molecular Weight(stack gas) $M_s$	$= Md(1-B_{ws}/100)+0.18B_{ws}$	= _____ lb/lb mol
Absolute Stack Pressure	$P_s = B_p + \text{static pressure}/13.6$	= _____ in Hg
Stack Velocity	$vs = K * C_p * ((\Delta p)^{0.5})_{ave} * (T_s / (P_s * M_s))^{0.5}$	= _____ ft/sec
Stack Area	$A_s = (\text{diameter}/24)^2 * \pi$	= _____ ft <sup>2</sup>
Flow Rate	$Q_{std} = 60 * (1-B_{ws}/100) * vs * A_s * (T_{std}/T_s) * (P_s/P_{std})$	= _____ dscfm

where:

$t_s$	=	Stack Temperature (°F)
$B_p$	=	Barometric Pressure (in. Hg)
static pressure	=	static pressure (in. Hg)
$K_p$	=	85.49 ft/sec
$C_p$	=	Pitot Tube Coefficient
$\Delta p$	=	Velocity Pressure (in H <sub>2</sub> O)
diameter	=	Stack Diameter (inches)
$T_{std}$	=	528 °R
$P_{std}$	=	29.92 in Hg

## CO<sub>2</sub> Adjustment for Incinerator Data

### Velocity Traverse and Calculations (Burner Only)

Stack Temp	$T_s = t_s + 460$	= _____ °R
Moisture in Stack Gas	$B_{ws}$	= _____ %
Molecular Weight(stack gas) $M_s$	$= Md(1-B_{ws}/100)+0.18B_{ws}$	= _____ lb/lb mol
Absolute Stack Pressure	$P_s = B_p + \text{static pressure}/13.6$	= _____ in Hg
Stack Velocity	$v_s = K * C_p * ((\Delta p)^{0.5})_{ave} * (T_s / (P_s * M_s))^{0.5}$	= _____ ft/sec
Stack Area	$A_s = (\text{diameter}/24)^2 * \pi$	= _____ ft <sup>2</sup>
Flow Rate	$Q_{std} = 60 * (1-B_{ws}/100) * v_s * A_s * (T_{std}/T_s) * (P_s/P_{std})$	= _____ dscfm

where:

$t_s$	=	Stack Temperature (°F)
$B_p$	=	Barometric Pressure (in. Hg)
static pressure	=	static pressure (in. Hg)
$K_p$	=	85.49 ft/sec
$C_p$	=	Pitot Tube Coefficient
$\Delta p$	=	Velocity Pressure (in H <sub>2</sub> O)
diameter	=	Stack Diameter (inches)
$T_{std}$	=	528 °R
$P_{std}$	=	29.92 in Hg

## CO<sub>2</sub> Adjustment for Incinerator Data

$$\text{CO}_2 \text{ adj} = \frac{\text{CO}_2 \text{ contributed by burner, \% volume of stack gas corrected to test conditions}}{\% \text{CO}_2 \text{ (dry, burner only)} * (Q_{\text{std (burner only)}} / Q_{\text{std (waste and burners)}}) * \text{BT}} = \underline{\hspace{2cm}} \%$$

$$\text{CO}_2 \text{ (waste only)} = \frac{\text{CO}_2 \text{ in stack gas due to waste}}{\% \text{CO}_2 \text{ (dry waste and burners)} - \text{CO}_2 \text{ adj}} = \underline{\hspace{2cm}} \%$$

$$c_{\text{adj}} = \frac{\text{Particulate concentration at 12\% CO}_2}{c_{\text{(waste and burners)} * ((12\%) / \text{CO}_2 \text{ (waste only)})} = \underline{\hspace{2cm}} \text{ gr/scf}$$

where:

BT = Fraction of test time all burners are operating

$c_{\text{(waste and burners)}}$  = Particulate concentration (gr/scf)

$c_{\text{adj}}$  = Particulate concentration at 12% CO<sub>2</sub> (gr/scf)



## **Appendix K**

### **Opacity Monitor Drift Calculations**

Sources covered under IAC 567-25.1(1) through 25.1(4) are required to operate and maintain continuous opacity monitoring systems (COMS). One of the requirements for the COMS is that the 24-hour zero and upscale calibration drifts shall not exceed 4%.

The zero and calibration drift shall be calculated using the equation below.

A = initial zero reading  
B = final zero reading  
C = initial upscale reading  
D = final upscale reading

$$\text{Zero Drift} = A - B$$

$$\text{Upscale Calibration Drift} = [(D - C) - (B - A)]$$

The initial values are the readings from the previous 24 hr period; the final values are the current day's zero and calibration values.

These values are to be calculated every day to ensure the COMS meets the drift requirements and are to be maintained on site according to IAC 567-25.1(5).

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